1999-12

Feasibility of standardizing automated laboratory analyzers on-board U.S. Naval Ships

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THESIS

FEASIBILITY OF STANDARDIZING AUTOMATED LABORATORY ANALYZERS ON-BOARD U.S. NAVAL SHIPS

by

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December 1999

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1999	Master's Thesis

4. TITLE AND SUBTITLE **FEASIBILITY OF STANDARDIZING AUTOMATED LABORATORY ANALYZERS ON-BOARD U.S. NAVAL SHIPS**	5. FUNDING NUMBERS
6. AUTHOR(S) Soyk, Debra R..	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT *(Maximum 200 words)*

There are 75 Naval ships that have a medical laboratory aboard and laboratory technicians assigned (HM 8506-Advance Medical Laboratory Technicians) to perform testing. The purpose and function of laboratory technicians are to assist health care providers in 1) confirming or rejecting a diagnosis, 2) providing guidelines in patient management, 3) establishing a prognosis, 4) detecting disease through case finding or screening, and 5) monitoring follow-up therapy. Currently, no shipboard laboratory is configured quite the same. Even though the testing requirements are similar, the type of instrumentation and methodology used to accomplish testing varies from ship to ship. This research provides insight into the feasibility, effects, and benefits of standardizing automated laboratory analyzers aboard Navy ships. The author examined the current doctrine, selection, procurement and provisioning of shipboard laboratories and their impacts on training and fleet medical support. The findings show the overall effect of standardizing laboratory analyzers is improved combat readiness. The concerns of medical departments that led to non-standard analyzer procurement will be alleviated with fielding of the standardized equipment. Scarce resources, including funding, shipboard warehousing and laboratory space, and training resources are maximized.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Standardizing Laboratory Equipment, Automated Analyzers	92
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500 **Standard Form 298 (Rev. 2-89)**
Prescribed by ANSI Std. 239-18 298-102

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FEASIBILITY OF STANDARDIZING AUTOMATED LABORATORY ANALYZERS ON-BOARD U.S. NAVAL SHIPS

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Submitted in partial fulfillment of the
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MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

There are 75 Naval ships that have a medical laboratory aboard and laboratory technicians assigned (HM 8506-Advance Medical Laboratory Technicians) to perform testing. The purpose and function of laboratory technicians are to assist health care providers in 1) confirming or rejecting a diagnosis, 2) providing guidelines in patient management, 3) establishing a prognosis, 4) detecting disease through case finding or screening, and 5) monitoring follow-up therapy. Currently, no shipboard laboratory is configured quite the same. Even though the testing requirements are similar, the type of instrumentation and methodology used to accomplish testing varies from ship to ship. This research provides insight into the feasibility, effects, and benefits of standardizing automated laboratory analyzers aboard Navy ships. The author examined the current doctrine, selection, procurement and provisioning of shipboard laboratories and their impacts on training and fleet medical support. The findings show the overall effect of standardizing laboratory analyzers is improved combat readiness. The concerns of medical departments that led to non-standard analyzer procurement will be alleviated with fielding of the standardized equipment. Scarce resources, including funding, shipboard warehousing and laboratory space, and training resources are maximized.

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I. INTRODUCTION

A. BACKGROUND

There are 75 Naval ships that have a medical laboratory aboard and laboratory technicians assigned (Hospital Corpsman (HM) 8506-Advance Medical Laboratory Technicians) to perform testing. The purpose and function of laboratory technicians are to assist health care providers in 1) confirming or rejecting a diagnosis, 2) providing guidelines in patient management, 3) establishing a prognosis, 4) detecting disease through case finding or screening, and 5) monitoring follow-up therapy [Ref. 1]. The laboratory technicians test body tissues and fluids to determine the causes and cures of diseases. Because the tests performed are so vital to medical treatment, the laboratory technician must know not only how to perform these tests with scientific precision and accuracy but must be well educated in the underlying scientific principles.

Currently, no shipboard laboratory is configured quite the same. Even though the testing requirements are similar, the type of instrumentation and methodology used to accomplish testing varies from ship to ship. When an Advanced Medical Laboratory Technician reports aboard ship, they must train themselves to become competent at operating the shipboard laboratory analyzers. Since there are many manufacturers of laboratory equipment and the technology used is quite different from analyzer to analyzer, it may be several months before the technician is competent to test, report, and perform maintenance on the analyzers.

Due to the variability in laboratory instrumentation, it is impossible to share resources with other shipboard laboratories. Reagents and spare parts can not be shared between analyzers produced by different manufacturers. Due to the low volume of tests

performed onboard ship, non-standardization of analyzers prohibits shipboard laboratories from benefiting from the cost-per-test contracts now available to shore medical facilities.

This research is intended to describe the benefits achievable from the standardization of laboratory instrumentation and costs associated with standardization. It will address Navy Doctrine, laboratory equipment, and laboratory technician training.

B. OBJECTIVE OF THE RESEARCH

This research will examine the feasibility, effects, and benefits of standardizing automated laboratory analyzers aboard Navy ships. The testing of laboratory specimens has become so technically advanced that sophisticated, state-of-the-art analyzers are necessary to perform clinical diagnostic analysis. This research will examine the current doctrine, selection, procurement and provisioning of shipboard laboratories and their impacts on training and fleet medical support. The objective is to analyze Navy medical doctrine, laboratory equipment and laboratory technician training and make recommendations for improvements to laboratory equipping policies supporting fleet medical operations.

C. RESEARCH QUESTIONS

The primary question that this thesis answers is: How can standardizing automated laboratory analyzers benefit the Navy? In addition to answering the primary question, subsidiary research questions are addressed:

- Who are the key manufacturers of laboratory analyzers? Are these manufacturers capable of providing service and supplies during contingencies?
- Should shipboard laboratory analyzers be purchased or leased?

- What cost savings are associated with standardization of laboratory analyzers?
- What are the potential benefits to fleet personnel (laboratory technicians, physicians, and crewmembers)?
- Does doctrine support standardization of laboratory instrumentation and training?

D. SCOPE AND LIMITATIONS

This thesis consists of an examination of the current policy for equipping shipboard laboratories. It will identify and evaluate manufacturers of laboratory instrumentation capable of meeting shipboard requirements. This research will also include the benefits associated with the standardization of laboratory equipment and cost analysis information. This thesis will conclude with recommendations for standardizing analyzers aboard Navy ships.

E. LITERATURE REVIEW AND METHODOLOGY

Publication, instructions, and working papers from Bureau of Medicine and Surgery (BUMED), Joint Readiness Clinical Advisory Board (JRCAB), Navy Medical Logistics Command (NAVMEDLOGCOM), and various Military Medical Departments were reviewed for areas relating to laboratory medicine. This provided background information on current policies and practices.

Information obtained from interviews with personnel stationed aboard ships, NAVMEDLOGCOM, JRCAB, and at the Navy School of Health Sciences (NSHS) provided additional insight and perspectives concerning equipping shipboard laboratories.

F. CHAPTER OUTLINE

Following the introduction chapter, which provides a general overview of laboratory medicine and shipboard laboratories, this thesis is organized into four additional chapters:

- Chapter II provides an overview of shipboard medical laboratories. It provides a summary of the doctrinal shipboard laboratory mission, the five echelons of medical care during a conflict, current laboratory configuration, and a description of medical laboratory technician training.
- Chapter III provides a synopsis of the Navy's evaluation of commercial manufacturers of medical laboratory equipment.
- Chapter IV presents an analysis of the benefits associated with standardizing laboratory instrumentation.
- Chapter V contains the conclusions, recommendations, and areas for further research.

II. SHIPBOARD MEDICAL LABORATORY OVERVIEW

A. INTRODUCTION

The end of the Cold War has resulted in regional instability and ambiguous threats that replaced the single fixed threat of global war posed by the former Soviet Union. The emergence of a this new security environment, coupled with the realities of a decreasing defense budget, significant reductions in the Department of Defense's (DoD's) infrastructure and competing domestic priorities have resulted in a re-evaluation and revision of our national security policy and military strategy. "Forward – From the Sea" reflects the Navy's strategy for the post-Cold War era [Ref. 2]. It represents a shift from global war to armed regional conflicts and joint operations from the sea.

B. NAVY MEDICAL DOCTRINE

The primary mission of Navy Medicine – providing Health Service Support (HSS) to operational forces of the Navy and Marine Corps - has not changed. However, the environment and the threat to our forces are constantly evolving. The new naval strategy has created the need for significant changes in doctrine, organization, operational requirements, education, training and acquisition involving fleet medicine [Ref. 3]. Navy Medicine remains vigilant, keeping pace with force requirements and the needs of fleet commanders. Standardization of medical practices has become a mechanism for engineering some of these changes.

The basic elements of health care support are the medical personnel and the medical facilities of individual ships. Health care resources of individual ships are designed and provided for the support of ship's company and embarked personnel.

The number and type of health care personnel and the extent of medical facilities, equipment, and supplies on any ship are generally based on a ship's mission, complement, and embarked personnel. The minimum shipboard HSS staffing requires one independent duty corpsman (IDC) who is responsible for providing Echelon I level (self aid/buddy care) medical care. The various echelons of medical care will be further discussed below. Information this thesis provides involving Echelons of care is a synopsis of material in Naval Warfare Publication (NWP) 4-02 [Ref. 3].

Because of space limitations, most afloat HSS capabilities cannot be increased solely by personnel augmentation. Aircraft carriers, amphibious assault ships and some auxiliary ships are fitted with facilities to accommodate one or more assigned Medical Department Officers as well as hospital corpsmen of various Navy Enlistment Classifications (NEC's)[Ref. 3]. Ancillary support service is required to assist the Health Care Provider (HCP) in the delivery of complete medical care. Laboratory medicine is an integral part of this ancillary support. Shipboard laboratories are currently not equipped to provide the same level of care from ship to ship. The care a patient receives depends on the equipment used to process and analyze patient specimens. Standardization is important in today's fleet laboratories in order to limit variability from ship to ship and ensure consistent patient care. This thesis focuses on naval shipboard laboratory equipment, personnel, doctrine, and training.

During a conflict, the Navy's medical assets for combat casualty care are organized into five separate levels, or echelons, of medical care [Ref. 3]. These levels flow from the battlesite within the theater of operations back to the continental United States (CONUS). Echelons III and IV are provided from the three service component

(i.e., U.S. Navy, U.S. Army, and U.S. Air Force) resources in support of all casualties caused by combat. The theater of operations is divided into two zones, the Combat Zone and the Communications Zone.

The Combat Zone is defined as the area of combat operations; this includes all sea, land, and airspace within that area. Echelons I, II, and III fall with the Combat Zone [Ref. 3]. Table 2-1 displays Service capability based on specific levels of care [Ref. 4].

Table 2-1. Service Echelon of Care

Service	Biological Warfare	Echelon I	Echelon II	Echelon III
Army	Theater Area Medical Laboratory (TAML)	Self Aid/ Buddy Care Combat Lifesaver Combat Medic Battalion Aid Station	Forward/Main Support Battalion (BN) Medical CO (Division) Area Medical BN (Corp) Forward Surgical Teams	Combat Support Hospital Field Hospital General Hospital Blood Bank Platoon, Medical Logistics BN (MEDLOGBN)
Navy	Forward Deployable Lab (FDL)	Self Aid/Buddy Care Navy Corpsman	Surface Combatant Ships	Primary Casualty Receiving Treatment Ships (PCRTS) Fleet Hospital Ships (T-AHs)
Air Force	Theater Epidemiology Team	Self Aid/Buddy Care	Emergency Medical System (EMEDS)	Emergency Medical System (EMEDS)
Marine Corps		Self Aid/Buddy Care Navy Corpsman	Battalion Air Station or Wing Support Air Station (MAS)	Primary Casualty Receiving Treatment Ships (PCRTS) Fleet Hospital Fleet Hospital Ships (T-AHs)

The Communications Zone is defined as the area behind the Combat Zone, which is required to support combat operations. Echelon IV is in the Communications Zone while Echelon V, the final level, is in CONUS.

The echelon system is characterized by decreasing medical asset mobility with increasing capabilities as patients move from Echelon I through Echelon V. The concept of care at each echelon of the HSS system is constricted by the following four interacting factors [Ref. 3]:

1. Urgency of the patient's needs
2. Requirements for mobility of medical personnel and facilities
3. Capabilities, equipment, and supplies of HSS personnel
4. The workload at each echelon of care, relative to its treatment capacity

Echelon I care is functionally subdivided into three levels of expertise. The lowest level of expertise, Level I, is provided by nonmedical personnel at the scene and provides basic first aid (self or buddy care). The goal of this care is to minimize further injury and place the patient into the formal HSS response system. This level includes basic first aid and Basic Life Support (BLS) capability non-medical ship personnel.

The middle level of expertise in Echelon I care is provided by the shipboard medical personnel on the scene and provides basic evaluation and stabilization. In the fleet, independent duty corpsmen staff the medical departments of small ships and provide emergency care. Care rendered by hospital corpsmen includes examination and evaluation followed by emergency lifesaving measures [Ref. 3].

The highest level of expertise in Echelon I care is provided by a team of medical personnel and includes a more thorough evaluation, stabilization, and treatment capability. The patient will encounter initial contact with a physician at this level. Patients requiring additional care are prepared for MEDical EVACuation (MEDEVAC).

Echelon I also includes Marine Corps Battalion Aid Stations (BAS) and Shipboard Medical Aid Stations (MAS). The BAS or MAS is located near the "front line" but in what is considered a safe or secured area. This allows the physician to determine the appropriate care for these patients. Ancillary support is not always available at Echelon I. Medical laboratory technicians (HM 8506) may be assigned to a MAS ship to assist patient care by providing laboratory services [Ref. 3].

Echelon II provides initial resuscitative care in the form of surgical and medical resuscitation. Medical teams composed of surgeons, nurses, and medical technicians can perform advanced medical care. The initial resuscitative treatment phase is distinguished by the application of clinical judgement and skills by the medical team. The objective of this phase of treatment is to perform those emergency surgical procedures which, in themselves, constitute resuscitation and, without which, death or serious loss of limb or body function is likely to occur. Echelon II care approaches the same level of care available in a small community hospital. This form of care stabilizes patients for evacuation to an Echelon III medical facility. In the Marine Corps environment, Echelon II consists of Collecting and Clearing Companies and Surgical Support Companies. In a shipboard environment, a shipboard surgeon coordinates these tasks. The final Echelon II activity is the Casualty Receiving and Treatment Ships (CRTS) [Ref. 3]. Blood and blood products are available at Echelon II. Ancillary support, specifically the laboratory, is necessary for Echelon II medical care. Table 2-2 lists mandated laboratory tests required at Echelons II and III [Ref. 4].

Table 2-2. Mandated Laboratory Tests

Biological Warfare	Echelon I	Echelon II	Echelon III
No Deployable Medical Systems (DEPMEDS) items No Patient Diagnostic Care	No DEPMEDS Laboratory Tests	Amylase Bilirubin Blood Drawing, Venous Blood Gas Estimation Blood Urea Nitrogen (BUN) Cardiac Phosphokinase (CPK) Creatinine Culture and Susceptibility Culture, Throat Electrolytes :Sodium (NA), Potassium (K), Chloride (Cl), Carbon Dioxide (CO2) Fecal Leukocytes Feces for Ova, Cysts and Parasites Glucose Hematocrit Occult Blood Partial Thromboplastin Time (PTT) Pregnancy (HcG) Protein Alanine Aminotransferase (ALT) Asparate Aminotransferase (AST) Cerebral Spinal Fluid (CSF), Cell Count with culture, glucose and protein Stool Culture Malaria Smears Urinalysis with specific gravity Wet Prep	Acid Fast Bacteria, Microscopic Alkaline Phosphatase ALT Amylase Anaerobe Identification Anti-Streptolysin O (ASO)Titer Bilirubin Blood Drawing, Venous Blood Gas Estimation BUN Calcium Chlamydia Culture Cholesterol Complete Blood Count (CBC) CPK Creatinine Culture and Susceptibility Culture, Blood Culture, Wound Culture, Throat Electrolytes (NA, K, Cl, CO2) Fecal Leukocytes Feces for Ova, Cysts and Parasites Fibrinogen and FSP Gonorrhea Identification Glucose Gram Stain Hematocrit Human Immunodeficiency Virus (HIV) Mononucleosis Spot Test Occult Blood Partial Thromboplastin Time) Pregnancy Protein Prothrombin Time (PT) Red Blood Cells (RBC's), Frozen –Thaw and Wash 2 units Rapid Plasma Reagin (RPR) CSF, Cell Count with culture, glucose and protein Sputum culture Stool culture Malaria smears Triglycerides Type and Cross, 4 units Tzanck smear Urinalysis with specific gravity Urine culture Wet Prep

Echelon III provides a higher level of surgical and medical resuscitative capability. Echelon III consists primarily of two important medical assets; Hospital Ships (T-AHs) and Combat Zone Fleet Hospitals. Combat Zone Fleet Hospitals are prepositioned around the world, ready to be deployed. Both of these assets allow the medical team the ability to perform complicated surgical procedures as well as provide acute medical care. Echelon III assets provide highly skilled specialty definitive care in order to mend and return the patients to full duty as quickly as possible [Ref. 3]. Definitive care is adapted to the precise conditions of the patient. Definitive care is normally provided by a fully staffed hospital, and embraces those endeavors necessary to complete the patient's recovery. Ancillary services have advanced capabilities, particularly in the laboratory support function. A Laboratory Officer and one or more HM 8506s are assigned to Echelon III level facilities. Table 2-3 lists the laboratory equipment requirement based on laboratory tasks at the various levels of Care [Ref. 4].

Table 2-3. Laboratory Equipment Requirements Based on Doctrine

Biological Warfare	Echelon I	Echelon II	Echelon III
No laboratory analyzer No patient diagnostic care	No laboratory analyzer	Blood Gas and electrolyte Analyzer Chemistry analyzer (Glucose, BUN, Creatinine, Amylase, Bilirubin, CPK, ALT, AST, Protein) Hematocrit Coagulation Analyzer Cholinesterase Test System CSF (Protein and Glucose)	Blood Gas and electrolyte Analyzer Chemistry analyzer (Glucose, BUN, Creatinine, Amylase, Bilirubin, CPK, ALT, AST, Protein, Alkaline Phosphatase, Cholesterol, Triglycerides) Hematology Analyzer Coagulation Analyzer (PT/PTT, Fibrinogen, FSP) Cholinesterase Test System CSF (Protein and Glucose)

Echelon IV is comprised of outside the continental United States (OCONUS) Medical Treatment Facilities (MTF's) and a Communications Zone Fleet Hospital. These are capable of definite subspecialty rehabilitative care in order to return the patient to duty or prepare them for further MEDEVAC to CONUS MTF's. Echelon IV level care is not provided on board U.S. Naval ships [Ref. 3].

Echelon V is the final level of care. It is composed of CONUS MTF's as well as the Veteran's Administration (VA) and civilian hospitals. These facilities are used when a patient requires extensive rehabilatory treatment. Echelon V level care is not provided on board U.S. Naval ships [Ref. 3].

Each of these echelons can provide capabilities equal to the proceeding level, plus additional capabilities, for incrementally progressive care. In general, as the medical unit becomes more sophisticated, the requirement for laboratory testing is increased.

Many amphibious ships have secondary roles after they deploy their complement of troops ashore [Ref. 4]. Specific ships of the amphibious task force are designated as primary CRTS to provide Echelon II HSS for the landing force during amphibious operations. Primary CRTS's are equipped with laboratory capabilities to support surgical procedures. Ships designated as primary CRTS include the Amphibious Assault Ship, Helicopter (LPH); Amphibious Assault Ship, General Purpose (LHA); and Amphibious Assault Ship, Multi-purpose (LHD). Appendix A, Tables 1-3 provides the medical capabilities of these ships [Ref. 3].

The Commander, Amphibious Task Force (CATF) may designate amphibious ships as secondary CRTS. These may include any ship class which, at a minimum, has the capability to receive and treat casualties, provided appropriate medical material and

personnel are available. Ships designated as secondary CRTS's include the Amphibious Transport Dock (LPD); Dock Landing Ship (LSD); Tank Landing Ship (LST); and Amphibious Command Ship (LCC) [Ref. 3]. Appendix A, Tables 4-7 provides the medical capabilities of each of these ships.

The aircraft carrier's primary mission is to provide a forward-deployed offense. One of the aircraft carrier's supportive missions is to provide medical support of the crew and members aboard [Ref. 4]. This is facilitated by a self-sufficient carrier hospital that has a 65-bed capacity. In addition, this Echelon III facility is equipped with a full service laboratory.

T-AHs are afloat surgical hospitals designed for extensive Echelon III HSS of combat operations at sea and ashore. Currently, there are two T-AHs in the U.S. Navy inventory, USNS Mercy (T-AH 19) and USNS Comfort (T-AH 20). The primary mission of the T-AH is to provide a mobile, flexible, rapidly responsive afloat medical capability, and acute medical and surgical care in support of amphibious task forces, Marine Corps, Army, and Air Force elements, forward-deployed elements of the fleet, and fleet activities located in areas where hostilities may be imminent [Ref. 3]. Each T-AH listed above is equipped with a full service laboratory. Moreover, these T-AH's have a Laboratory Officer and several HM 8506's assigned to them.

C. CURRENT LABORATORY CONFIGURATION

The Naval Air Forces, U.S. Pacific and U. S. Atlantic Fleets are composed of similar type ships with similar type missions. Although there are differences in ship designs, the basic functions of the laboratory on board these vessels remain the same.

Each medical laboratory is required to perform certain basic laboratory tests in order to provide basic lifesaving and sustaining care. The laboratory must be able to provide the Medical Officer with a minimum hematology report which consists of a White Blood Cell Count (WBC), a hematocrit (HCT) and/or a hemoglobin (HGB) values. The minimum chemistry report must consist of glucose, Blood Urea Nitrogen (BUN) and electrolytes (sodium, potassium, chloride, and carbon dioxide) values [Ref. 5].

The size of medical laboratories on board ships varies greatly from a 5 foot by 12 foot space on board the USS CORONADO (AGF 11), to two 18 foot by 20 foot spaces on the USS BOXER (LHD 4). Laboratory analyzers placed on board ships are subjected to various space limitations. Many analyzers are large, bulky, and require too many consumable products, which are infeasible on board the smaller ships.

A medical requirements list, called an Authorized Medical Allowance List (AMAL) [Ref. 6] is established for each Navy or Marine Corps unit which may deploy during either a contingency operation or normal (day-to-day) operations. These units encompass various Navy and Marine Corps assets such as CRTS, combatant ships, and hospital ships. These lists are the authorized allowance of medical equipment and consumable supplies, which are required to accomplish the medical mission of the unit. An AMAL is determined based on the mission and capacity of the medical assets in the unit [Ref.6]. For example, a laboratory AMAL for the Hospital Ships is a complete list of the laboratory supplies needed to support 1000 casualties for 30 days. This list is based on a combat casualty care mission which is trauma/surgery intensive. These lists represent the authorized inventory of equipment and supplies that are to be maintained on board at all times. Allowances may be augmented to meet specific deployment

requirements or patient care related demands. Supplies and equipment cannot be ordered from the depot or procured by a local medical instruction. Per the AMAL instruction, analyzers should not be replaced or surveyed unless the item becomes unserviceable [Ref. 6].

The process by which these AMAL are produced involves the cooperation of various communities within the Navy Medical Department. In order to decide which items will be included in an AMAL, an ad-hoc committee is convened. This committee includes personnel from the various physician communities, nursing services, ancillary service (laboratory, pharmacy, etc.), bio-medical repair services, and administrative communities (logistics, supply, financial management, etc.). The members of this committee work together to produce a list which balances the clinical requirements with the monetary and logistical constraints of the mission. Bureau of Medicine and Surgery (BUMED) Instruction 6700.13G, Management and Procurement of Authorized Medical and Dental Allowance List Material for Fleet Units, states the policy to effectively manage medical and dental inventories and to establish responsibilities to develop, maintain, and review the AMALS. The Chief, BUMED, approves AMAL revisions before distribution. The Chief of Naval Operations must approve revisions that have a cumulative cost over $100,000. [Ref. 6]

The ad-hoc committee is required to conduct a review of the contents of the AMALs every two years [Ref. 6]. This review is done to assure that the AMALS are updated to reflect current changes in the practice of medicine and technology. Between reviews, any medical personnel may request changes be made to an AMAL by completing and submitting an AMAL change request form (ACR) through the chain of

command. The goal of the review is to ensure the standard of care practiced by deployed units is not significantly different from ship to ship or that practiced at CONUS medical treatment facilities (MTFs). Appendix B, Tables 1-4, lists the AMAL laboratory requirements for LPD, LSD, AGF, and CVN ship classes.

As listed in the laboratory AMALS, the equipment and supplies for clinical diagnostic hematology is limited to the performance of manual hematology analysis on some ships and the Coulter T890 on others. Manual technology is no longer practiced in the hospital environment. In addition, manual analysis is considered antiquated by medical professionals. The laboratory technician's only exposure to this procedure is during the classroom phase of this training. The Coulter T890 is outdated, is labor and maintenance intensive, and has no ability to recognize abnormal or unusual cells. Limited training with manual analysis and the operation of outdated analyzers have caused shipboard medical departments to purchase off-the-shelf hematology analyzers with funds from their operating budget. Each ship may perform laboratory testing using analyzers produced by different manufacturers and technology. Since the analyzer is not authorized by the AMAL, purchasing and paying for supplies and consumables necessary to operate the analyzer, becomes the responsibility of the medical department.

In addition to hematology analyzers, some shipboard laboratories have automated chemistry analyzers while others do not. Ships, other than carriers and T-AH's, perform diagnostic chemistry testing using the DT-60. The manufacturer of this analyzer no longer produces that particular model, and it is becoming increasingly difficult to obtain spare or replacement parts to maintain its operation. In an attempt to alleviate some of the problems associated with the DT-60, these ships have been equipped with two additional chemistry instruments, the I-STAT and the Piccolo [Ref. 5]. Each system is from a

different vendor, utilizes different reagents and consumables, and none has the ability to process more than one patient or test at a time. Laboratory technicians do not receive training on the DT 60, I-STAT or Piccolo while attending Medical Laboratory Technician school or while assigned ton CONUS hospitals. If time allows, the departing technician will provide "on-the-job" training to the newly assigned technician, if not the technicians must teach themselves. If the technician has to learn the operation on his/her own, there may be a procedure manual available or the manufacturer may provide technical assistance via telephone. Neither source is always available, but the technician is still responsible for learning how to operate the analyzer.

It requires two analyzers to complete chemistry analysis aboard the carriers. Most carriers are equipped with the Dupont ACA IV and either the Dupont Na^+K^+ or the Beckman Na^+K^+ analyzers [Ref. 7]. Neither of these instruments operates efficiently nor are technicians given training on their operation. Technicians are "self-taught" in the operation of these instruments.

There are many problems associated with the current doctrine and the manner in which shipboard laboratories are outfitted. The lack of technician training, purchasing non-standard analyzers, and the use of multiple analyzers to provide diagnostic testing will be discussed in Chapter IV of this thesis.

D. MEDICAL LABORATORY TECHNICIAN TRAINING

Clinical laboratory medicine contributes more hard scientific objective data and information to a patient's medical care than any other single source. The purpose and function of laboratorians through clinical pathology and laboratory medicine are to assist clinicians in 1) confirming or rejecting a diagnosis, 2) providing guidelines in patient management, 3) establishing a prognosis, 4) detecting disease through case finding or screening, and 5) monitoring follow-up therapy [Ref. 1]. The principal areas of practice

in the laboratory are chemistry, hematology, microbiology, urinalysis, immunohematology and immunology.

Laboratory medicine can be viewed as a bridging endeavor linking basic biological and physical sciences with medical principles. This bridging is not complete without the appropriate support mechanism of modern equipment and training of all laboratory personnel.

Satisfaction in laboratory performance is attained through quality testing of specimens and to assist health care providers in an effective, efficient, and economic manner. Although accuracy and precision have always been prerequisites to good laboratory service, promptness of a lucid result report is equally critical to overall excellence in patient care. The generation of quality laboratory values must be inherent by explicit adherence to basic laboratory principles through proper collection, handling, and processing of each patient specimen. This is best accomplished by ensuring medical laboratory technicians receive a proper education that prepares them to perform independent clinical analysis.

Clinical Laboratory Scientists (CLS), or Medical Laboratory Technicians (MLT), test body tissues and fluids to determine the causes and cures of diseases, and provide this valuable information to the physician. Because the tests performed are so vital to medical treatment, the clinical laboratory scientist must know not only how to perform these tests with scientific precision and accuracy, but must be well educated in the underlying scientific principles.

In addition to performing laboratory tests using the latest biomedical technology, CLS professionals also interpret test results in conjunction with patient information, and communicate their meaning to other healthcare team members. Interpretation of

laboratory measurements depends on knowledge of normal, expected ranges for the values of each analyzer operated [Ref. 1].

Prior to October 1998, there were two NECs for medical laboratory technicians: HM 8501 (a basic laboratory technician) and HM 8506 (advanced laboratory technician). Due to unregulated Physician Office Laboratories (POLs) and concerns relating to the quality of laboratory results, Congress enacted the Clinical Laboratories Improvement Act of 1988 (CLIA-88). CLIA-88 required that certified laboratories employ only personnel who meet established qualifications in training, experience, job performance and competency. Currently, CONUS medical laboratories are certified by the College of American Pathologists (CAP), the Joint Commission on Accreditation of Healthcare Organization (JCAHO), the American Association of Blood Banks (AABB), and the Federal Food and Drug Administration (FDA). In order to improve the quality of health care provided and to not jeopardize certification, basic laboratory technician training was discontinued in favor of a more intensive training program.

HM 8506s attend a intensive 52/53-week course, which includes training in hematology, microbiology, immunology, blood banking and chemistry at one of three medical facilities: Naval School of Healthcare Science (NSHS) Portsmouth, Virginia, NSHS San Diego, California, or School of Health Science, Fort Sam Houston, Texas. Table 2-4 lists the general educational courses required by students at NSHS Portsmouth, Virginia [Ref. 8]. The first six months of the training is classroom instruction and the remaining six months is spent in a medical laboratory setting to receive "hands-on" training. The medical laboratory technician participates in over 800 hours of supervised, clinical internship. This program is designed to prepare the HM 8506 to obtain, process, transport, analyze specimens and report laboratory values.

Table 2-4. General Education Courses

Course Number	Course Title	Block 1 (6 weeks)	Credits
BIO 100	Basic Human Biology		3
CHM 110	Survey of Chemistry		3
MDL 110	Urinalysis and Body Fluids		2
MTH 126	Mathematics for Allied Health		2
TOTAL			**10**
		Block 2 (6 weeks)	
BIO 205	General Microbiology		4
CHM 122	Health Science Chemistry		4
MDL	Clinical Hematology		3
TOTAL			**11**
		Block 3 (6 weeks)	
MDL 210	Immunology and Serology		2
MDL 225	Clinical Hematology		3
MDL 251	Clinical Microbiology		3
ENG 101	Practical Writing I		3
TOTAL			**11**
		Block 4 (6 weeks)	
MDL 216	Blood Banking		3
MDL 252	Clinical Microbiology II		2
MDL 262	Clinical Chemistry and Instrumentation II		4
TOTAL			**9**
		Naval Hospital Portsmouth	
MDL 109	Blood Collection Techniques		1
MDL 140	Clinical Microscopy I		**2**
MDL 266	Clinical Chemistry Techniques		4
MDL 276	Clinical Hematology Techniques		4
MDL 277	Clinical Immunohematology and Immunology Techniques		4
MDL 278	Clinical Microbiology Techniques II		4
TOTAL			**19**
Non-credit course MDL 280	Clinical Correlations		
TOTAL MINIMUM CREDITS			**60**

During classroom training, medical laboratory technicians are given instruction concerning basic principles, techniques, and vocabulary applicable to all phases of medical laboratory technology. Hematology classroom instruction teaches the

fundamentals of the study of blood and blood formation as well as instruction on how to perform manual hematology procedures. Clinical Chemistry instruction introduces the methods of performing biochemical analysis of clinical specimens. The student performs clinical chemistry methodologies and operation of typical instrumentation in a clinical laboratory setting. Figure 2-1 provides a description of the medical laboratory courses [Ref. 9].

COURSE DESCRIPTIONS

MDL 109 Blood Collection Techniques (1 credit): Introduces student to the clinical facilities. Teaches medical ethics, hospital organization, and laboratory work flow and patient interaction skills, along with techniques for venipuncture, dermal puncture, blood culture collection and isolation technique. Laboratory 3 hours per week.

MDL 110 Urinalysis and Body Fluids (2 credits): Studies the gross, chemical and microscopic techniques used in the clinical laboratory. Emphasizes the study of clinical specimens, which include urine, feces, cerebrospinal fluid, blood, and exudates. Introduces specimen collection and preparation. Lecture 1 hour + 3 lab hours per week.

MDL 125 Hematology I (3 credits): Teaches fundamentals of the study of blood and blood formation. Lecture 2 hours + 3 hours lab per week.

MDL 140 Clinical Microscopy I (2 credits): Focuses on urinalysis studies including physical and chemical properties, microscopic techniques. Emphasizes the significance of abnormal results. Lecture 1 hour + 3 hours lab per week.

MDL 210 Immunology and Serology (2 credits): Teaches the principles of basic immunology, physiology of the immune system, diseases involving the immune system, as well as serologic procedures. Lecture 1 hour + 3 hours lab per week.

MDL 216 Blood Banking (3 credits): Teaches the fundamentals of blood grouping and typing, compatibility testing, antibody screening, component preparation, donor selection, and transfusion reactions and investigation. Lecture 2 hour + 3 hours lab per week

MDL 225 Clinical Hematology II (3 credits): Teaches advanced study of blood, abnormal blood formation, and changes seen in various diseases. Lecture 1 hour + 6 hours per week.

MDL 251 Clinical Microbiology I (3 credits): Teaches handling, isolation, and identification of pathogenic microorganisms. Emphasizes clinical techniques of bacteriology. Lecture 2 hours + 3 lab hours per week.

MDL 252 Clinical Microbiology II (2 credits): Teaches handling, isolation, and identification of pathogenic microorganisms. Emphasizes clinical techniques of mycology, parasitology, and virology. Lecture 2 hours + 3 lab hours per week.

MDL 262 Clinical Chemistry and Instrumentation II (4 credits): Introduces methods of performing biochemical analysis of clinical specimens. Teaches instrumentation involved in a clinical chemistry laboratory, quality control, and the ability to recognize technical problems. Lecture 2-3 hours + 3 lab hours per week.

MDL 266 Clinical Chemistry Techniques (4 credits): Includes performing of clinical chemistry methodologies and operation of typical instrumentation in a clinical laboratory setting. Laboratory 12 hours per week.

MDL 276 Clinical Hematology Techniques (4 credits): Stresses performing hematological and coagulation methods and operation of typical instrumentation in a clinical laboratory. Laboratory 12 hours per week.

MDL 277 Clinical Immunohematology and Immunology Techniques (4 credits): Deals with performing techniques, procedures, and interpretations in Blood Banking and Serology in a clinical laboratory setting. Laboratory 12 hours per week.

MDL 278 Clinical Microbiology Techniques (4 credits): Includes performing of techniques, procedures, and identification of microorganisms in a clinical laboratory setting. Laboratory 12 hours per week.

MDL 280 Clinical Correlations and Pathophysiology: Introduces the practice of laboratory medicine and encourages the development of critical thinking skills. Includes control and methodology selection criteria. Lecture 2 hours per week.

Figure 2-1. Medical Laboratory Technician Course Description

Clinical rotation training allows the student to operate and perform analysis on patient specimens in a hospital laboratory. This rotation assists the MLT student in understanding the concepts needed to proficiently perform routine laboratory activities. During this rotation, the technician will develop a strong working knowledge and understanding of laboratory operations. The medical laboratory technician is rotated throughout the various departments of the laboratory. During this clinical rotation, the HM 8506 acquires a working knowledge of automated laboratory analyzers. Much of the knowledge gained during this training is due to "hands on" operation of the equipment.

Day-to-day operations require meticulous detail to each step in the analytic process. A technician learns to identify and correct erroneous results caused by improper operation and/or maintenance of machine. A certified Medical Technologist allows the technicians to operate the instrument and perform analysis on actual patients but with direct supervision, though students are not allowed to report the patient results. Exposure to various manufacturers and models is limited to those analyzers available in the laboratory. Manual procedures are not practiced or performed during the clinical rotation.

To ensure the accuracy and precision of laboratory testing, procedure manuals are mandated by laboratory accrediting agencies [Ref. 1]. A procedure manual details the specific techniques necessary for performing each laboratory test. They must be readily available at all laboratory instruments for use by staff. Students are required to read and become familiar with these Standard Operating Procedure (SOP) manuals. An instrument-specific manual must be available for use for each analyzer operated in a laboratory setting [Ref. 1].

As a student rotates through the various sections of the laboratory, they learn to operate numerous analyzers. Each section (chemistry, hematology, microbiology, urinalysis, immunohematology and immunology) has automated equipment. Operation of each analyzer is different and each requires specific steps to properly perform diagnostic testing. Each instrument has its own unique operating requirements and strict adherence to these protocols for each instrument is required to produce a valid diagnostic report. A technician is given specific instruction and training on each analyzer to ensure proficiency.

Students are required to maintain a C average to graduate. Grade point average is not the only requirement for graduation, the students must be able to proficiently operate all analyzers, interpret results, and perform general laboratory duties such as processing specimens. Upon graduation, the HM 8506 is eligible for a variety of laboratory assignments, including shipboard.

E. CHAPTER SUMMARY

The mission of Navy laboratory medicine is to provide top quality health services whenever needed, in support of military operations and to members of the Armed Forces. The goal is to have consistent medical support from ship to ship that is comparable to that practiced at CONUS medical treatment facilities. Current ship configuration based on established doctrine does not allow for this consistent or comparable care.

Updating AMALs is the first step towards the standardization of medical care, however concerns exist with the mandated use of manual procedures and outdated analyzers. The laboratory technician training needs to correlate with shipboard laboratory functions. Chapter III examines how the Navy is addressing these issues.

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III. MARKET EVALUATION OF COMMERCIAL MANUFACTURERS OF LABORATORY ANALYZERS

Joint Vision 2010 states "Currently, our Armed Forces are the best trained, best equipped and most ready force in the world...Military operations are planned knowing that leaders truly understand the requirements, the equipment is operable and safe, and men and women at the cutting edge have the skills and character to execute their tasks successfully" [Ref. 10].

Due to the changing roles, missions, physician requirements, and laboratory equipping and training practices, there was a need to update the AMALs to reflect current technology and to standardize laboratory practices and analyzers. The first step in updating the AMALs was to assess the needs and requirements of the fleet medical laboratories. Once those requirements were identified, an evaluation of commercial analyzers was performed to ensure that the best laboratory equipment is available to support fleet medicine.

Within DoD, there are two separate entities, Naval Medical Logistics Command (NAVMEDLOGCOM) and the Joint Readiness Clinical Advisory Board (JRCAB), that conducted commercial manufacturer evaluations. Each used different approaches for the identification of the laboratory requirements aboard ships and in the selection of manufacturers able to support those requirements. This chapter will discuss the different approaches used by NAVMEDLOGCOM and the JRCAB and the conclusions reached by each of the groups.

A. NAVAL MEDICAL LOGISTICS COMMAND

NAVMEDLOGCOM is located at Fort Detrick, Maryland and its mission is to provide and coordinate medical and dental material management and logistical support to operating forces and shore activities [Ref. 11]. NAVMEDLOGCOM is responsible for maintaining AMALs for the fleet and integrating fleet and hospital AMALS into the fleet's supply system processes.

NAVMEDLOGCOM requested that the Medical Departments of each ship with laboratory capabilities provide a list of laboratory tests currently being performed, the volume of testing for each analyte, and a "wish list" of those tests medical providers desire but were not available. An analysis of this data was conducted. The findings indicated that Medical Departments wanted the capability of performing: 1) automated hematology analysis to include a Complete Blood Count (CBC) with differential, 2) a chemistry analyzer with the ability to perform those tests necessary to complete a physical examination and liver function profile, and 3) an immunoassay instrument capable of performing quantitative pregnancy tests (bHCG), CK-MB, Prostate Specific Antigen (PSA), and Chlamydia assays [Ref. 12). Medical departments listed their requirements based on day-to-day operations while in port and/or underway and on their medical mission during a contingency.

In addition to having automated analysis and a wider array of testing capability, the medical departments requested that the automated analyzers be similar to those found in shore-based medical facilities so that emergency supplies, parts, and technical support would be available while deployed. Also, they desired the medical laboratory technicians to be trained on the analyzers that they are responsible for operating. Two additional

requirements were identified for the chemistry analyzers: 1) the ability to batch specimens (test multiple patients) and 2) the ability to perform multiple tests on a patient [Ref. 12].

Based on these findings, NAVMEDLOGCOM needed to identify those commercial manufacturers of laboratory analyzers that could meet the needs of the fleet medical departments. The following notice was placed in the Commerce Business Daily (CBD) on February 9, 1999 [Ref. 13]:

> The Naval Medical Logistics Command is researching the available clinical analysis analyzer available to perform clinical diagnostic tests aboard U.S. Navy ships. Over the next five years, the Navy anticipates replacing approximately 75 clinical analyzers in shipboard applications. The equipment must be capable of operation when located on an unstable base (i.e. the analyzer can not require a level countertop) due to the pitch and roll encountered aboard ships. The equipment should operate from a power source of 115 volts, 60 Hertz. Reagents must be stable. The Navy is looking for a shelf life not less than six months from time of delivery. The analyzer must minimize operator time. The volume of tests performed on each analyzer is fairly low, typically 2000 tests per year. The required test menu is fairly large, as listed below. It is not assumed that one analyzer can perform all of the required tests, so products which provide a substantial capability will be considered. REQUIRED TESTS: CBC, CBC WITH DIFF, ESR,PT/PTT, ABO/RH, CROSSMATC, SICKLE CELL, RPR, MONOSPOT, HCG, ANANINE AMINOTRANSFERASE, CALCIUM, CARBON DIOXIDE, CHLORIDE, CHOLESTEROL, CK-MB, CREATINE KINASE, CREATINE, GGT, GLUCOSE, HIGH DENSITY LIPOPROTEIN, LACTATE DEHYDROGENASE, MAGNESIUM, PHOSPHATE, POTASSIUM, SODIUM, TOTAL BILIRUBIN, TOTAL PROTEIN, TRIGLYGERIDE, UREA NITROGEN, URIC ACID. ADDITIONAL TESTS DESIRED: ACETAMINOPHEN, THYROID FUNCTIONS. If your company has a product or products which you wish considered, we request you forward comprehensive information to this command by close of business 11 Mar 99.

Four manufacturers of hematology analyzers and six manufacturers of chemistry analyzers responded to this notice. NAVMEDLOGCOM completed a review of the

corporations that responded to the CBD notice. The goal was to investigate the possibility of a total laboratory solution that would minimize the amount of instrumentation required in the laboratory, conform to the space limitations aboard ship, and meet financial budget constraints. Each analyzer was evaluated using the selection criteria listed in Table 3-1 [Ref. 14]:

Table 3-1. NAVMEDLOGCOM Selection Criteria

USER FRIENDLY	The instrument must be easy to troubleshoot, must be easy to run (by just reading a manual); easy to maintain.
RELIABLE	Ideally the instrument should have a long "mean time between failure rate" (the amount of times when a service technician from the company must repair the analyzer); have a support line which is available 24 hours per day, and be designed with minimal moving parts to provide ease of maintenance, troubleshooting, and allow for easy transportation.
CLINICALLY ACCEPTABLE	The technology should provide high quality results. The instruments should have large menus (when applicable) and excellent Quality Control Packages.

As an additional criterion, the analyzer had to be from a proven world wide diagnostic vendor capable of providing global support and be able to meet surge requirements.

After a thorough analysis of the analyzers and manufacturer's capabilities NAVMEDLOGCOM posed two recommendations: one for the hospital ships and another for all other ships with clinical laboratories. Appendix C, Table 3-6 and Table 3-7 provides the diagnostic capabilities of each analyzer. Abbott Laboratories was selected as the single source solution for all ships other than hospital ships. Selection of Abbott Laboratories was based on several factors: 1) Abbott Laboratories has the largest U.S.

technical and service support system for diagnostics among all vendors. It is able to handle and support the military needs globally. 2) All of its products are available on the FSS. 3) Abbott is the largest supplier of diagnostic analyzers in the world. 4) Greater than 95% of military labs worldwide use Abbott products. 5) Abbott offers 24- hour telephonic support [Ref. 14].

Table 3-2 lists the breakdown of individual instrument selection based on selection criteria [Ref. 14].

Table 3-2. Instrument Selection

TYPE OF TEST: **IMMUNOASSAY**	MANUFACTURER/MODEL: **ABBOTT Imx**
USER FRIENDLY	Three step operation when performing test . Fully reconstituted reagents, calibrators, and controls. Only 4 moving parts.
RELIABLE	MTBF: 56 weeks. On-site personnel can replace all parts. Hot line available to assist with parts replacement.
CLINICALLY ACCEPTABLE	On-board system verification to ensure correct results every time. Most widely accepted immunoassay system in the world, over 30,000 currently placed systems
TYPE OF TEST: **HEMATOLOGY**	MANUFACTURER/MODEL: **CELL DYN 1700**
USER FRIENDLY	Requires on 30ul of sample. Provides an 18-parameter result with screening differential. Requires calibration once every 6 months. Stores up to 5000 results. Calculates means, SD's and C.V.
RELIABLE	MTBF: 27 weeks. On-site personnel can replace all parts. Hot line available to assist with parts replacement. Minimal moving parts. Probe is self-cleaning to eliminate manual wiping and minimize sample carry-over or contamination.
CLINICALLY ACCEPTABLE	Proven track record on proficiency tests and uses same technology as all comparable cell counters. On board QC package ensures system performance

Table 3-2. Instrument Selection (cont.)

TYPE OF TEST: **CHEMISTRY**	MANUFACTURER/MODEL:**ABBOTT ALCYON**
USER FRIENDLY	This analyzer can perform all the current chemistry testing performed by the current three-analyzer configuration. It has a throughput of 300 tests per hour; therefore multiple patients with different tests can be performed at the same time.
RELIABLE	MTBF: similar to other instruments. System has nine moving parts, which minimizes the need for service.
CLINICALLY ACCEPTABLE	Will perform adequately if maintained. Current menu includes electrolytes, liver function tests, routine chemistry analytes, and a full lipid panel. Menu can be customized to the needs of the particular environment such testing required for a potential chemical weapons threat

The manufacturer and analyzer recommended for use aboard the hospital ships was the Vitros 950 produced by Johnson and Johnson Clinical Diagnostics. This analyzer was recommended for the following reasons: 1) Cost-Per-Test arrangement (discussed in Chapter IV), 2) Both hospital ships have been, and will concurrently use a Vitros 250, which is totally compatible with the Vitros 950 in terms of reagent usage, technician training, and technical support, and 3) Trained technicians from MTF's who currently use the Vitros 950 will deploy with these ships [Ref. 15].

B. JOINT READINESS CLINICAL ADVISORY BOARD

The JRCAB serves as an executive-level body responsible in support of the DoD medical readiness mission by enhancing Service medical department's cooperation, interoperability, and operational flexibility, while achieving efficient health service in support and conservation of resources. [Ref. 4]. The patient condition (PC), clinical treatment brief, and the medical material serve as modeling constructs for the Task, Time,

Treater database (TTT). The TTT is an algorithm in which a battlefield scenario is created and the expected casualty type is generated. Based on casualty type, medical treatment and laboratory testing requirements are determined. The board reviews and validates: 1) defined patient conditions, 2) required clinical treatments to medically address patient conditions by level of care, and 3) specific medical material needed to undertake the clinical treatment [Ref. 4].

Clinical treatment briefs and their associated TTT file database form the core of medical readiness planning for the first three levels of in-theater care. To ensure the best analyzers were provided to support all Service laboratories while deployed, the JRCAB did a clinical review of the TB and the TTT.

The laboratory panel of the JRCAB wanted to ensure that laboratory analyzers have: 1) capability for immediate care, 2) reduced weight and cube [Ref. 4].

Once the laboratory equipment requirements were established, the JRCAB determined the frequency of laboratory testing based on the TTT. The frequency numbers listed in Table 3-3 is not based on any one particular casualty stream [Ref. 4]. Depending on the battlefield scenario, the frequency would vary based on the casualty stream of that scenario. The data was used to determine the scope and robustness of laboratory analyzers needed to support patient conditions at the various levels of care.

Table 3-3. Frequency Rates of Tests at Echelon II and III

Lab Task (test)	Frequency at Echelon II	Percent of Lab Task, Echelon II	Frequency at Echelon III	Percent of Lab Task, Echelon III
Acid Fast Bacteria, Microscopic	0	0.00	1	0.06
Albumin	0	0.00	3	0.17
Alkaline phosphatase	0	0.00	12	0.69
Amylase	1	0.27	17	0.98
Anaerobes	0	0	0	0.00
ASO titer	0	0.00	0	0.00
Bilirubin	2	0.54	34	1.96
Blood collection	63	16.89	78	4.50
Blood culture	1	0.27	25	1.44
Blood Gas	9	2.41	79	4.56
BUN	12	3.22	75	4.33
Calcium	0	0.00	6	0.35
CBC	31	8.31	309	17.84
Chlamydia	0	0.00	4	0.23
Cholesterol	0	0.00	2	0.12
CPK	0	0.00	10	0.58
Creatinine	10	2.68	74	4.27
CSF, count and differential	1	0.27	8	0.40
CSF, culture	1	0.27	7	0.46
Dipstick (Blood, Urine, CSF, Nasal)	0	0.00	0	0.00
Drug screen, blood	0	0.00	0	0.00
Drug screen, urine	0	0.00	0	0.00
Electrolytes	18	4.83	202	11.66
Fecal leukocytes	6	1.61	5	0.29
Fibrinogen/FSP	0	0.00	4	.023
GC identification	0	0.00	6	0.35
Glucose	6	1.61	46	2.66
Glucose, CSF	4	1.07	14	0.75
Gram stain	3	0.80	16	0.92
HCG	6	1.61	7	0.64
HIV	0	0.00	5	0.40
Magnesium	0	0.00	3	0.17
Malaria smears	4	1.07	9	0.17
Myoglobin	0	0.00	3	0.29
Occult Blood	7	1.88	5	2.83
Ova & parasites	12	3.22	7	0.40
Phosphorus	0	0.00	3	2.66
Protein	1	0.27	11	3.12
Protein, CSF	1	0.27	8	0.81
PT	1	0.27	54	0.46
PTT	1	0.27	49	0.58
RBC Cholinesterase	4	1.07	8	4.04

Table 3-3. Frequency Rates of Tests at Echelon II and III (cont.)

Lab Task (test)	Frequency at Echelon II	Percent of Lab Task, Echelon II	Frequency at Echelon III	Percent of Lab Task, Echelon III
RBC's, Frozen-Thaw and wash (2 units)	0	0.00	70	0.40
RPR	0	0.00	7	0.17
SGOT	2	0.54	46	3.35
SGPT	2	0.54	58	0.46
Spin HCT	69	18.50	38	0.29
Sputum culture	0	0.00	13	0.00
Stool culture	1	0.27	0	0.52
Throat culture	0	0.00	1	0.06
Triglycerides	0	0.00	3	0.06
Tzanck smear	0	0.00	1	8.89
Urinalysis, microscopic	0	0.00	0	0.00
Urinalysis, specific gravity	24	6.43	154	0.00
Urine culture	0	0.00	6	0.35
Urine protein	0	0.00	0	0.12
Wet prep/KOH	4	1.07	2	0.12
Wound culture	0	0.00	4	.023
TOTAL	**373**	**100.00**	**1732**	**100.00**

The JRCAC panel reviewed four hematology analyzers. Table 3-4 is the panel's evaluation of hematology analyzers [Ref. 4]. Each analyzer was evaluated on its ability to perform the following tests: CBC to include platelets, granulocytes, mononuclear cells, hematocrit, CSF cell count, and malaria smears. The analyzers were also evaluated on the following requirements:

- Portable, durable, lightweight, and encased (less than 50 pounds)
- Operator friendly
- Low maintenance
- Extended shelf life (ideally up to 12 months without refrigeration)
- Throughput less than or equal to five minutes
- Capacity: 12 patients per hour
- Operates on 120/240; 50/60 MHZ or battery

- Optional battery back-up
- Power loss protocol
- Prints reports
- Calibration stability
- Overall application For Level 2 Care
- RS-232 Compatible
- Optional data management capability
- Operational environment requirements.

Table 3-4. JRCAB Hematology Evaluation

Requirement	Spirit	QBC	Ichor	Coulter AcT10
Portable, light weight (<50lbs)	60 lbs	30 lbs, flexible footprint	31 lbs	30 lbs
Operator Friendly	No	NO	YES	YES
Low Maintenance	Yes, very hands on	Yes, more manipulation	YES	YES
Reagent Shelf life ≥ 12 mths w/o refrigeration	YES	18 months	9-12 months	13 months
Throughput ≤ 5 min, Capacity 12/hr	55	Spin time 5 min; 90 seconds	90 seconds; 40/hr	60 seconds
120/240 V50/60 or battery back-up	Yes; no battery	Yes; no battery	Yes; no battery	Yes; no battery
Power loss protocol	NO	Reset; but no data	NO	NO
Print results	Optional	Optional	YES; exterior	YES
RS-232 compatible	YES	YES	YES	YES
Optional Data Management	Stores last ten days	NO	Smart card w/ last test result; Optional additional memory	Optional
Calibration Stability	Autocalibration	YES, calibration rod	Smart Card	Standard calibration with Smart Card
CBC w/differential	YES	2 part differential plus platelets	16 parameters	10 parameters; absolute lymphocyte count
Overall Performance	2	4	4	4
Average for Level 2/3 care	29	42	46	46

No analyzer evaluated met all the requirements, the Ichor and Coulter instruments scored the highest in overall performance. The panel decided that the prevalence of the Coulter technology, ease of repair and longevity of the un-refrigerated reagent shelf life, place the Coulter at an advantage to the other instruments. The Coulter AcT 10 was selected as the hematology analyzer for Echelon II and III care.

The JRCAC panel reviewed four chemistry analyzers. Table 3-5 displays the evaluation of the instruments [Ref. 4]. Each analyzer was evaluated on its ability to perform the following tests: Alkaline phophatase, Amylase, Bilirubin, BUN, Calcium, Cholesterol, CPK, Creatinine, Electrolytes, Glucose, Myoglobin, Protein, Albumin, Magnesium, Phosphorous, SGOT, SGPT, CSF Glucose and Protein, Triglycerides. The analyzers were also evaluated on the following requirements:

- Portable, durable, lightweight, and encased
- Operator friendly
- Low maintenance
- Extended shelf life (ideally up to 12 months without refrigeration)
- Throughput less than or equal to 10 minutes
- Multiple analyte analysis
- Capacity: 25-50 test per hour
- Operates on 120/240; 50/60 MHZ or battery
- Optional battery back-up
- Power loss protocol
- Prints reports
- Calibration stability
- Overall application For Level 2 Care

Table 3-5. JRCAB Chemistry Evaluation

CHEMISTRY REQUIREMENTS	PICCOLO	DT 60	NOVA	I-STAT
Performs all analyte testing	YES, question regarding CSF	YES	Only glucose, BUN, electrolytes	Only glucose, BUN, electrolytes
Portable, Durable, lightweight, encased	YES; robust for size; rugged	55 lbs	90 lbs	18 ounce,handheld
Operator Friendly	Only 4 patient profiles/hour	YES; but hands on	YES	2 minute panels
Extended reagent shelf life	Refrigerated 18 months	Refrigerated 12 months	12 months room temperature	Refrigerated 6-12 months; Room temp. 14 days
Low Maintenance	YES, change filter only	YES	YES	YES
Throughput =/<10 minutes	NO	NO	60 seconds	2 minutes
Multiple analyte analysis	YES on same rotor	YES	YES	YES
Capacity: 20-50 tests	4/hour	Varies; 15 slide for electrolytes/hour	360 tests/hour	30-240/hour
Operates on 120/240; 50/60 MHZ or battery	YES	YES	YES	YES
Optional battery back-up	YES; 12 volt	NO	YES	YES
Power loss protocol	Unknown	Unknown	Unknown	YES
Prints reports	Yes; no digital reading	YES	YES	YES
Calibration stability	Software card update. One point calibration	Unknown	Automated, single point	YES, electronic checks
Environmental	59-90F; 95% non condensing	59-90F; 95% non condensing	Unknown	64-86F; 0-65% Humidity
Overall application for Level 2 care	4	3 (pieces of analyzer)	Weight limiting factor	Limited testing
Comments	$1/analyte	Cost	Low Cost/analyte. Electrodes seem simple to maintain	None
TOTAL	**42.5**	**34**	**32.5**	**47.5**

The Panel's evaluation of available chemistry instruments was difficult since there is not one instrument that meets all the clinical needs. The panel decided that a combination of the I-Stat for Point of Care testing and the Piccolo were the best combination for Echelon II and III [Ref. 4]. The I-Stat can support blood gas and electrolytes while the Piccolo can handle the other analytes. The Panel decided to retain the DT-60 on the AMALs list until the Piccolo can develop more comprehensive panels.

C. CHAPTER SUMMARY

There is a focused concern within the DoD to update and standardize medical laboratory equipment. The first step to accomplish standardization is to identify which analyzers are best equipped to satisfy fleet laboratory operational capabilities. There are two organizations within DoD, NAVMEDLOGCOM and JRCAB, that conducted market research to determine the key manufacturers of laboratory analyzers. Each manufacturer's analyzers were then evaluated based on specific criteria selected by each organization.

NAVMEDLOGCOM's selection criteria focused on the day-to-day laboratory requirements while in port, underway, or during a contingency. This evaluation gave consideration to analyzers that could perform mandated laboratory testing as well as the additional testing capabilities fleet physicians desired. Special consideration was given to the number of analyzers required due to space limitations and the needs of fleet medical departments, which included automated analysis and a wider array of testing capability. This evaluation resulted in the recommendation that Abbott Laboratory be the single source provider of laboratory analyzers for all ships other than the two hospital ships. Johnson and Johnson's Vitros 950 was recommended as the chemistry analyzer for the hospital ships. This proposal was based on several factors as discussed in this chapter.

JRCAB's selection criteria was based on the TTT database which analyzes laboratory testing requirements based on the type of casualties expected during different wartime scenarios. The decision on which manufacturers to evaluate was determined by frequency of laboratory tests as indicated by the TTT. The day-to-day operations of fleet medical were not considered in this evaluation. The panel did not recommend a single

source provider of laboratory analyzers. The JRCAB's decision supports current doctrine, providing only the instrumentation required supporting wartime echelons of care. One hematology analyzer and three chemistry analyzers were selected to provide this mandated laboratory support.

Doctrine delineates which ships are to provide only Echelon II level care. Medical departments are providing higher echelons of care than what doctrine has mandated and have purchased non-standard and non-authorized analyzers capable of supporting that care. The costs associated with providing this higher care level, a cost benefit analysis of standardizing laboratory equipment, and other potential benefits achievable through the standardization of laboratory instrumentation will be discussed in Chapter IV.

IV. ANALYSIS OF STANDARDIZING LABORATORY EQUIPMENT

A. INTRODUCTION

Chapter III identified the key manufacturers of laboratory analyzers, evaluated each analyzer and manufacturer against specific selection criteria, and offered recommendations for analyzers based on the selection process. A best value analysis of each analyzer was performed and will be discussed in this chapter. Included in this chapter will be a discussion concerning the costs associated with the current system of operating laboratories aboard ships with non-standard analyzers, as well as various alternatives to decrease current costs. This chapter will also examine the benefits that can be achieved through the standardization of laboratory analyzers aboard ships including enhanced training of personnel, reduced inventories, improved patient care and standard SOP's.

Current doctrine dictates how shipboard laboratories will be equipped based on the mission of ships during contingency operations. The JRCAB's evaluation was a reflection of that doctrine, while NAVMEDLOGCOM's evaluation included analyzers that would provide diagnostic value during normal operations. Medical departments, in an attempt to improve the medical readiness of the fleet, have been providing higher echelons of care than what doctrine has mandated. Non-standard analyzers have been the means of providing that care.

B. COSTS ASSOCIATED WITH CURRENT ANALYZERS

As discussed in Chapter II, manual hematology analysis or use of an outdated hematology analyzer are the current methods used to perform diagnostic hematology on

ships. Such methodologies were deemed unsatisfactory by fleet physicians, since they did not provide the information necessary to deliver quality and accurate medical care to fleet personnel. In attempt to improve laboratory testing capabilities and provide enhanced care to sailors and marines, each medical department purchased hematology analyzers available on the commercial market. This uncoordinated procurement resulted in a proliferation of non-standard and unauthorized analyzers throughout the fleet.

The cost of purchasing the supplies required to perform laboratory analysis with manual methodologies is negligible, however, the costs associated with the purchase of non-standard analyzers (not listed on AMAL) is considerable. The purchase price ranges from $9,750 - $19,500, which is funded by the medical department's operating budget. Supplies and reagents costs range from $5,000 to $10,000 yearly, depending on the number of tests performed. For those ships that have both the authorized instrument and one purchased by the medical department, these costs are additive.

Chapter II discussed the use of multiple chemistry analyzers to provide adequate patient care. The cost of maintaining various analyzers requires the purchase of reagents and supplies specific for each instrument. An example of reagent costs for one chemistry analyzer is listed in Table 4-1 [Ref. 5]. The number of analyzers aboard ship multiplies these costs accordingly.

Table 4-1. Chemistry Reagent Costs

Analyte	Workload/Year	Cost/Test in dollars	Total Cost
Triglycerides	3505	3.11	$10,910
Cholesterol	3505	2.71	9507
HDL	3505	3.01	10,559
Glucose	3480	1.47	5116
CO2	1690	2.76	4698
Chloride	1690	1.36	2298
BUN	1690	1.69	2687
Creatinine	1690	1.63	2755
Calcium	964	1.63	1566
Phosphorous	954	1.62	1736
Total Protein	1230	1.36	1673
Albumin	1230	1.36	1673
Alkaline Phosphatase	1230	1.36	1673
AST	1230	1.82	2239
ALT	1230	1.82	2239
Total Bilirubin	1230	1.59	1958
Direct Bilirubin	1230	1.59	1958
GGT	1230	2.78	3419
Amylase	1230	4.44	5461
LDH	1230	2.04	2509
Uric Acid	954	1.85	1769
Total Cost/Year		**Avg. cost/test: $2.18**	**$78,363**

The information provided for reagent costs does not include the cost of quality control and calibration materials. Laboratory accreditation agencies, AABB, FDA, and CAP, require that control specimens, at more than one concentration, should be assayed for all tests being used to provide patient values [Ref. 1]. At least two levels of quality control specimens must be tested daily, for each analyte, prior to the use of the instrument for patient testing [Ref. 1]. Those same agencies require that laboratory instrumentation be calibrated at least twice yearly. Quality control and calibration materials are additional costs incurred to maintain laboratory equipment. Each analyzer must be operated and maintained to accreditation standards. Multiple analyzers on board the ship increases the cost of these additional supplies and reagents. Non-standardized analyzers do not allow for economies of scale when purchasing supplies and creates additional inventories that require storage space.

The use of non-standard analyzers was an attempt by fleet medical departments to improve the quality of care provided to fleet sailors and Marines. Manual analysis, outdated technology and inoperable analyzers had a direct impact on the ability of health care providers to deliver high quality medical care to the fleet. Being able to respond to a medical crisis when needed, keeping the fleet healthy, and returning injured or ill personnel to duty as rapidly as possible is the mission of Navy Medicine. Doctrine limited the capability of the laboratory and did not provide medical departments with the resources needed to accomplish their mission.

The procurement of commercial analyzers gave medical departments the ability to provide immediate and necessary care in a timely and effective manner, but at a cost. The result of purchasing these analyzers was the proliferation of non-standard instrumentation throughout the fleet. Though medical care was improved, the cost of maintaining multiple analyzers is estimated to be more than the cost associated with standardized analyzers. As discussed in Chapter II, the training of personnel on non-standard equipment was difficult. Each instrument has its own specific requirements for operation, maintenance, supplies, reagents, and spare parts. Space is required to warehouse these analyzer specific supplies. The logistics and training burden associated with the non-standard analyzers was clearly increased.

C. KEY MANUFACTURER'S COST EVALUATION

An assessment of the key manufacturers was performed in Chapter III. The price associated with the purchase of each analyzer is listed in Table 4-2 and Table 4-3 [Ref. 16].

Table 4-2. Hematology Analyzers

HEMATOLOGY ANALYZERS: PURCHASE VICE LEASE						
Manufacturer	Abbott 1700		Coulter MDII		Coulter AcT	
	Lease	Purchase	Lease	Purchase	Lease	Purchase
	$2859/yr	14,296	$2828/yr	$19,500	No Lease	$14,000
Manufacturer	Biochem Spirit		Biochem Cap Piercer		Biochem Lite	
	Lease	Purchase	Lease	Purchase	Lease	Purchase
	No Lease	11,750	No Lease	$12,750	No Lease	$9,750
Manufacturer	Elan Hemocount					
	Lease	Purchase				
	No Lease	$14,000				

Table 4-3. ChemistryAnalyzers

CHEMISTRY ANALYZERS: LEASE VICE PURCHASE						
Manufacturer	Abbott Alcyon		Elan ATAC 8000		Elan ATAC 6000	
	Lease	Purchase	Lease	Purchase	Lease	Purchase
	$10,000	$54,000	No Lease	$59,000	No Lease	$32,000
Manufacturer	I-STAT		Roche Reflotron		Chiron FAST	
	Lease	Purchase	Lease	Purchase	Lease	FAST Purchase
	No Lease	$9,750	No Lease	$6,065	$9,372	$25,000

Several manufacturers offered the option of leasing their analyzers at a substantially lower price. This lease price did not include the cost of reagents required to perform and calibrate each test. Leasing is a very attractive option if the volume of testing is large, which was not the case on most Naval ships. Due to the low volume, the cost associated with each test was as high as $15 compared to the current cost of less than $2.50. The expense of performing the expected number of tests, as historically documented, would have been double the price of purchasing the analyzer and needed supplies. Though leasing was evaluated, the prohibitive price eliminated leasing as an option for all but the hospital ships.

After a review of each analyzer based on the selection criteria, NAVMEDLOGCOM recommended Abbott Laboratories as the source for all three analyzers required for shipboard laboratory analysis. By selecting one manufacturer as a single vendor solution, economic leverage, training of personnel and a simplified procurement process are realized. Abbott Laboratories will provide the three analyzers for approximately $83,000 per ship (see Table 4-4 for a breakdown of prices [Ref. 14]). Reagent, supplies, and spare part prices are not significantly reduced per instrument. Money saved will be a result of the decreased number of instruments and or economies of a centralized, volume procurement. When consolidating to one source, additional support requirements are eliminated; funding is more economically applied without any reduction in capability.

Table 4-4. Single Vendor Cost Advantage

INSTRUMENT	SINGLE VENDOR COST*	PURCHASED INDIVIDUALLY
IMx	$17,000	$24,000
Cell Dyne 1700	$13,000	$14,296
Alcyon	$53,000	$54,000
TOTAL	$83,000	$92,296

*This is an open market price, FSS pricing and buying in volume may result in lower pricing.

The manufacturer and analyzer recommended for use aboard the hospital ships was the Vitros 950 produced by Johnson and Johnson Clinical Diagnostics. Due to the large volume of testing anticipated for each hospital ship, approximately 250,000 tests per year per ship, leasing on a cost-per-test basis is financially rewarding. Leasing the Vitros 950 with reagents and consumables on a five-year cost-per-test basis costs the Government $58,100 per year per ship or approximately 18 cents per test. The lease arrangement provides each ship with the hardware, training and maintenance required to

successfully conduct needed laboratory testing [Ref. 15]. Leasing the two analyzers resulted in savings of over $400,000 because the Government did not have to purchase the two analyzers. Included in the lease agreement is free software and technological updates, should they occur during the life of the lease. This lease also includes the cost of training two technicians per ship at the Johnson and Johnson's training complex. The current analyzer aboard each ship is the Vitros 250; the reagents and supplies used to operate the 950 are compatible for use on the 250. Additional reagents, quality control material and calibration supplies will not be required.

An added benefit of selecting the Vitros 950 is that the technicians responsible for operating the analyzer are currently trained and use the instrument daily at the MTFs where they are currently assigned. The many benefits of leasing on a cost-per-test arrangement will be discussed in the recommendations section of this thesis.

The JRCAB's recommendation did not address the need for immunological testing nor did it decrease the number of analyzers required to perform the necessary laboratory tests. There were no cost savings associated with that panel's recommendation nor did it address the problem of training personnel on multiple systems. The JRCAB decision does not offer any improvements to the manner in which medical departments can provide care to the fleet.

D. REDUCED INVENTORIES

The current system of outfitting shipboard laboratories with multiple instruments for each area of clinical testing creates unmanageable inventories of supplies, reagents, consumables, and spare parts. Each instrument requires its own specific supply system. This creates a large volume of inventory requiring storage space. As discussed in

Chapter II, space is very limited onboard ship. Laboratory supplies become a logistical burden during deployment due to space constraints.

Standardizing laboratory equipment will reduce this inventory. There will no longer be a need to purchase supplies and reagents from different vendors or for multiple analyzers. Inventories will be limited to the amount of material required to operate three standard analyzers. Space allocated for laboratory supplies can be decreased, potentially providing for increased patient workload or expansion of services for the laboratory.

E. ENHANCED TRAINING

Education of laboratory personnel is essential to promoting quality service and competent technicians. The technician, Navy Medicine, but most importantly, the patient, reaps the benefits as the laboratory technician enhances his or her knowledge base. Appropriate training in instrument performance, maintenance, and quality control procedures are essential for quality patient care. Quality personnel performance determines the quality of laboratory values; thus establishing and maintaining high levels of performance are crucial to laboratory operations. Technicians must receive thorough training on instrumentation and procedures. Technical skills are paramount to the delivery of accurate, timely and quality results. The ease with which technicians can optimally perform their work and the extent to which they can function as a part of the health care team to accomplish the goal of high quality patient care is determined by how well the technician is trained. As the technology increases and instrumentation becomes more sophisticated, the training a technicians receives must be as accurate and timely as possible.

As discussed in Chapter II, laboratory technicians are not currently receiving "hands on" training for the laboratory equipment aboard ships. The variation among existing analyzers found on ships makes it difficult to train technicians on all the possibilities of equipment they may encounter. The laboratory technician may have no formal training with the analyzer on board the ship because of the various models/manufacturers available. The HM 8506 must teach themselves how to properly operate, calibrate, and troubleshoot these instruments.

Training is the most important aspect for the proper operation of laboratory analyzers. Unless the individual performing the task has the skill and knowledge required to accurately and proficiently process, test, and interpret results, the information provided is of little medical value. As the learning curve theory suggests, a worker learns as he or she works; and the more often a worker repeats an operation, the more efficient the worker becomes. It also suggests that the more a worker performs a task, the more proficient ther worrker will become. It requires months of training and hands on experience to become proficient in the operation of automated analyzers.

Standardization of instrumentation would greatly enhance the training a HM 8506 receives. Standardization would establish manufacturer, model, and technology used to accomplish laboratory testing aboard ship. Classroom education would then focus on training technicians who will be operating independently on ships without oversight or support by Laboratory Officers. Hospitals, where students accomplish clinical rotations, would have the same standard analyzers available for performing actual patient testing.

Practice, repetition, and exposure to analyzers at the start of MLT training can be accomplished by standardizing instrumentation on ships and placing those same

instruments in the classroom. When transferring from ship-to-ship or ship-to-shore, the only training required of the technician would be familiarization with workflow patterns of that particular facility.

Improving a technician's training ultimately enhances the quality of care sailors and Marines receive while deployed. Laboratory technicians provide necessary medical information critical to the care of sick and injured patients. Being trained and able to respond in a timely and accurate manner, is the keystone to laboratory medicine. Doctors can render appropriate care in a timely manner only if the laboratory performs the test correctly. Increasing technician's training ultimately leads to improved medical care that results in keeping the forces healthy and on the job.

F. IMPROVED PATIENT CARE

The consequence of a lack of training is a technician who does not have the necessary skills required to operate instrumentation properly. Self-training on highly complex diagnostic analyzers can lead to improper testing or invalid test values which could result a patient receiving inadequate care. The primary mission of the Navy Medical Department is to assist with the health and medical readiness of personnel and provide necessary medical resources to care of the sick and injured member of the fleet in peace and war. This does not happen if medical personnel are not adequately trained.

The most important impact of standardizing laboratory analyzers is that the accuracy and quality of the lab results are improved which provides the doctor with the correct information needed to treat the patient. Standardizing analyzers will allow the training of technicians on the same analyzer. Patients on any ship will be examined with the same level of diagnostic accuracy. This will reduce the potential of technical error

and increase diagnostic confidence. The laboratory technicians will now be able to deliver a greater level of premium performance to enhance patient care and do so in a standardized manner equal to shore MTFs.

Mending a patient and allowing the patient to return to full duty as quickly as possible is the result of improved medical care. Fleet medicine's mission is to provide the medical treatment required to maintain, preserve, and restore the combat power of the force. Inherent in this objective are the requirements to return personnel to duty as expeditiously as possible and to minimize morbidity and mortality in those who cannot be returned to duty in a timely manner. Effective laboratory operations are a cornerstone in ensuring fleet combat readiness.

G. STANDARD OPERATING PROCEDURES

As stated in Chapter II, SOP's document all important laboratory functions and are mandated by laboratory accrediting agencies to be available for use by all laboratory instrumentation. Laboratory technicians do not receive SOP writing instruction during their 52- week training course. The current system of allowing the purchase of non-standard equipment requires that technicians prepare SOP's for each analyzer.

To ensure accuracy and precision of laboratory testing, procedure manuals are written. For the proper operation of analyzers, SOPs on standard equipment would supplement manufacturers manuals and provide a standard and approved methodology for all procedures. The National Committee for Clinical Laboratory Standards (NCCLS has developed a set of requirements for technical procedure manuals and must include the following elements (if applicable) [Ref. 18]:

- Principle of test (summarized)
- Specimen required (also any special patient preparation)
- Material used: reagents, standards, controls, special supplies
- Instrumentation, including calibration protocols and schedules
- Step-by-step directions
- Frequency and tolerance limits of controls
- Expected values, (normal ranges, values requiring special notification)
- Procedure notes (linearity or detection limits)
- Limitations of method (interfering substances)
- References
- Effective date and schedule for review
- Distribution
- Author

Preparing a procedural manual is labor intensive, requires in-depth knowledge of the instrument, access to laboratory reference materials and a computer. The shipboard laboratory technician is currently unprepared for this task. Many shipboard laboratories have SOP's that are improperly written, lacking vital information or may not exist. This responsibility could be eliminated with standardized instrumentation.

SOP's for shipboard analyzers would be distributed to the students at the onset of training. The students would use these manuals as they begin learning how to operate the equipment. Any problems or concerns with the manuals could be corrected while in training. At the completion of the MLT, the student would be provided with both a hard copy and computer disk with the correct and updated version of the SOP. There would be no need for the technician to prepare SOP's while assigned to a ship, as all equipment would be standard. Changes or updates would be accomplished by NSHS personnel and then electronically issued to the ship's medical departments.

H. CHAPTER SUMMARY

Current doctrine authorizes the use of manual analysis or outdated technology as the operating capabilities for shipboard laboratories. This chapter addressed the costs associated with the current system of outfitting laboratories and the cost savings linked with the standardization of laboratory analyzers aboard Naval ships. The current practice of purchasing non-standard equipment is how shipboard Medical departments augment mandated laboratory practices. This course of action does allow physicians the capability to improve the care provided to the fleet, but increases the cost of operating a laboratory, requires extra space to store the additional supplies, and limits the ability to train personnel.

Selection of a single vendor source as a supplier of standard laboratory equipment would result in substantial cost savings and reduce the number of analyzers required to outfit a ship board laboratory. Other potential benefits of implementing a standard laboratory system include decreased inventories, enhanced technician training, improved patient care, and standardized procedures manuals were evaluated in this chapter. Chapter V contains the conclusions and recommendations of this thesis.

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V. CONCLUSIONS AND RECOMMEDATIONS

A. CONCLUSIONS

The findings of this research indicate that DoN will realize many benefits by standardizing laboratory equipment onboard ships. The most important benefit gained is the improved quality of care to our sailors and Marines. Shipboard patients will be treated with the same level of diagnostic technology and capability regardless of Echelon. The benefits analysis indicates that substantial savings will be realized by selecting one manufacturer as a single Navy. Standardizing analyzers will enhance the training and ultimately, the proficiency of medical laboratory technicians. Technicians will report to fleet duty possessing the knowledge and skills necessary to provide critical laboratory service enhancing the "Protect the Force" tenet of Joint Vision 2010. Standardization of laboratory instrumentation will reduce the technical error and increase diagnostic capabilities of shipboard medical departments thus improving fleet combat readiness. Doctrine must be changed to support the laboratory requirements needed to support the day-to-day operations of fleet medical departments and provide improved to shipboard personnel. The cost of this improved care will be significant; the cost to outfit one ship is approximately $83,000.

The overall effect of standardizing laboratory analyzers is improved combat readiness. The concerns of medical departments that led to non-standard analyzer procurement will be alleviated with fielding of the standardized equipment. Scare resources, including funding, shipboard warehousing and laboratory space, and training resources are maximized.

B. RECOMMENDATIONS

Based on the findings and conclusions of this research, standardization of laboratory equipment will work if the following actions are effectively implemented and managed:

1. Fully Fund the Standardization Project

All systems should be purchased and installed in a short time frame to realize the benefits from economies of scale purchasing and to eliminate non-standard equipment in the fleet. A phased-in approach would only contribute to the variation and number of analyzers being used.

2. Select One Manufacturer as a Single Vendor Source

By selecting one manufacturer, economic leverage and a simplified procurement process are realized. When consolidating to one source, additional support requirements are eliminated; funding becomes focused on the source. This allows for simplified contracting procedures, which minimizes time, money and variation to the end user and decreases duplication of effort.

3. Train Technicians on Standardized Equipment

A MLT student's education should begin with instruction on instruments that they will be responsible for operating in the fleet. Navy Medicine must invest in the training and education of fleet personnel to prepare the technician for sea duty and ensure their proficiency. To ensure all students meet training requirements, standard instruments must be placed in the NSHS's classrooms and in the hospitals where students accomplish clinical rotations. A MLT student's education would begin with instruction on instruments that they will be responsible in the fleet. Having these instruments in the

classroom will aid and speed the learning process. Being exposed to the same analyzers for 52 weeks would greatly increase a technician's knowledge, skills, and experience for practical application in the clinical laboratory setting. The more time spent operating and performing routine maintenance on the instruments, the more confidence the technician will have in their own abilities. Continued exposure to the analyzers while at school will increase the technician's working knowledge and technical competence relating to the instruments. Practice is essential to learning new skills. Repetition of newly acquired skills improves performance and enhances the memory.

C. AREAS FOR FURTHER RESEARCH

This research suggests several areas that warrant further research:

- A shift in national security policy and military strategy has increased humanitarian mission; With this in mind, are fleet medical departments equipped to provide proper medical care to supported humanitarian patients?
- A study of the cost savings and benefits of standardizing laboratory equipment across DoD medical departments.
- A study of how the Prime Vendor program could be implemented when laboratory equipment is standardized.
- A study of laboratory usage rates at each Echelon of care to determine if current requirements are valid.

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APPENDIX A. MEDICAL CAPABILITIES OF AMPHIBIOUS TASK FORCE CASUALTY RECEIVING AND TREATMENT SHIPS

Medical Capabilities of Amphibious Task Force Casualty Receiving and Treatment Ships

LPH

AMPHIBIOUS ASSAULT SHIP (HELICOPTER)

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 1 Major Surgery, 1 Minor Surgery

Intensive Care Unit Beds: 2

Ward Beds: 14

Overflow Beds: 125

Ancillary Capabilities: Lab, X-ray, Dental

Complement: Ship's Company

- Medical Corps: 1
- Dental Corps: 1
- Nurse Corps: 0
- Anesthesia Provider: 0
- Medical Service Corps: 0
- Hospital Corpsmen: 9/10
- Dental Technicians: 2
- Dental Operations: 2

NOTE: A fleet surgical team is assigned when deployed.

Table 1

LHA

AMPHIBIOUS ASSAULT SHIP (GENERAL PURPOSE)

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 2 Major Surgery, 2 Minor Surgery

Intensive Care Unit Beds: 17

Ward Beds: 48

Overflow Beds: 360

Ancillary Capabilities: Lab, X-ray and Blood Bank

Complement: Ship's Company

- Medical Corps: 1
- Dental Corps: 1
- Nurse Corps: 0
- Anesthesia Provider: 0
- Medical Service Corps: 1
- Hospital Corpsmen: 16
- Dental Technicians: 3
- Dental Operations: 3

Table 2

LHD-

AMPHIBIOUS ASSAULT (MULTIPURPOSE)

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 6

Intensive Care Unit Beds: 17

Ward Beds: 47

Overflow Beds: 540

Ancillary Capabilities: Lab, Pharmacy, X-ray and Blood Bank

Complement: Ship's Company

- Medical Corps: 2
- Dental Corps: 1
- Nurse Corps: 0
- Anesthesia Provider: 0
- Medical Service Corps: 1
- Hospital Corpsmen: 18
- Dental Technicians: 4
- Dental Operations: 0

Table 3

LPD

AMPHIBIOUS TRANSPORT DOCK

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 1 Minor Surgery

Intensive Care Unit Beds: 0

Ward Beds: 13

Quiet/Isolation Beds: 4

Overflow Beds: 0

Ancillary Capabilities: Lab and X-ray

Complement: Ship's Company

Medical Corps: 1

Dental Corps: 0

Nurse Corps: 0

Anesthesia Provider: 0

Medical Service Corps: 0

Hospital Corpsmen: 6

Dental Technicians: 0

Dental Operations: 0

Table 4

LSD/LSD-41

DOCK LANDING SHIP

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 0

Intensive Care Unit Beds: 0

Ward Beds: 9 [LSD-41: 8]

Quiet/Isolation Beds: 2

Overflow Beds: 100

Ancillary Capabilities: Lab and X-ray

Complement: Ship's Company

- Medical Corps: 0 [LSD-41: 1]
- Dental Corps: 0
- Nurse Corps: 0
- Anesthesia Provider: 0
- Medical Service Corps: 0
- Hospital Corpsmen: 5
- Dental Technicians: 0
- Dental Operations: 0

Table 5

LST

TANK LANDING SHIP

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 0

Intensive Care Unit Beds: 0

Ward Beds: 4

Overflow Beds: 50

Quiet/Isolation Beds: 0

Ancillary Capabilities: Basic Lab

Complement: Ship's Company

- Medical Corps: 0
- Dental Corps: 0
- Nurse Corps: 0
- Anesthesia Provider: 0
- Medical Service Corps: 0
- Hospital Corpsmen: 3
- Dental Technicians: 0
- Dental Operations: 0

Table 6

LCC

AMPHIBIOUS COMMAND SHIP

GENERAL MEDICAL CAPABILITIES

Operating Rooms: 1 Minor Surgery

Intensive Care Unit Beds: 0

Ward Beds: 20

Overflow Beds: 0

Quiet/Isolation Beds: 4

Ancillary Capabilities: Lab and X-ray

Complement: Ship's Company

Medical Corps: 1

Dental Corps: 0

Nurse Corps: 0

Anesthesia Provider: 0

Medical Service Corps: 0

Hospital Corpsmen: 12

Dental Technicians: 0

Dental Operations: 0

Table 7

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APPENDIX B. AMAL

COG	AMAL	NSN	NOMEN	QTY
1I	7027	0102LF0159800	BLOOD DONOR CARD, DD-572, 100s	4
9L	7027	4110001764291	REFRIGERATOR MECHANICAL BIOLOGICALS 115V 60HZ AC 35CU FT MAXIMUM	1
9L	7027	4610009762420	DEMINERALIZER WATER ION EXCHANGE 115V 60HZ AC 10WATTS BENCH TYPE	1
9L	7027	6505013454468	GLUCOSE TEST SOLUTION 100GM 12 FL OZ BOTTLE 12 BOTTLES/PACKAGE	2
9L	7027	6510011139208	PREPARATION KIT BLOOD DONOR STERILE 20S	20
9L	7027	6515005842926	BALANCE AUTO SHUTOFF BLD COLLECTING-DISPENSING BAG 450ML CAP	4
9L	7027	6515011281407	BLOOD RECIPIENT SET INDIRECT TRANSFUSION Y TYPE NONTOXIC 48S	10
9L	7027	6515012796449	BRUSH CYTOLOGY 6.50"LG 0.75" BRISTLE SECTION 5.25" HDL DISP 100S	1
9L	7027	6515013142749	HOLDER BLOOD COLL-DISPEN BAG 2.688X2.250X2.125" PLASTIC O/A 144S	0.03
9L	7027	6515014328272	ADAPTER HYPODERMIC NEEDLE TO TUBIN U/W TERUFLEX BLD GAS 3000S	1
9L	7027	6515014476868	BLOOD COLLECTING-DISPENSING BAG AND DONOR SET PLAS 4000ML	20
9L	7027	6530002998631	PIPET DROPPING PLASTIC 3.5X.188"DISPOSABLE STERILE 100S	20
9L	7027	6530004776720	STERILIZATION TEST STRIP SET BACTERIAL SPORE BACILLUS SUBTILIS25	1
9L	7027	6530010480855	CUP SPECIMEN PLASTIC DISPOSABLE 2.625 INCH DIAMETER 4.5 OZ 500S	3
9L	7027	6530013695892	POWER SUPPLY ELECTRICAL MEDICAL EQUIP UNINTERRUPTIBLE SOURCE	1
9L	7027	6550001049319	DIFFERENTIATION DISKS MICROORGANISM BACITRACIN 0.04 UNIT 300S	1
9L	7027	6550001258750	MACCONKEY AGAR DEHYDRATED 1 LB	1
9L	7027	6550001331075	CULTURE MEDIUM SOYBEAN CASEIN DIGEST AGAR DEHYDRATED 1 LB	1
9L	7027	6550001391321	FORMALDEHYDE SOLUTION 37% 1 PT(473 ML)	6
9L	7027	6550001452800	CULTURE MEDIUM SALMONELLA SHIGELLA AGAR POWDER 1 POUND	1
9L	7027	6550004512612	BLOOD CELL STAINING KT 7ML BT RETICULOCYTE STAIN1 25MCL PIPET100	1
9L	7027	6550008805608	CULTURE MEDIUM MUELLER HINTON 500GM BOTTLE	1
9L	7027	6550009355870	CULTURE MEDIUM GC AGAR BASE DEHYDRATED 0.25 POUNDS	4
9L	7027	6550010079923	SENSITIVITY DISCS DIAGNOSTIC BACITRACIN 10 UNITS P/DISC 50S	2
9L	7027	6550010259855	BACTERIA CULTURE CONTROL DISC SET 10 VIALS	1
9L	7027	6550010313178	BACTERIAL INHIBITING LYOPHILLIZED POWDER 10ML 10S	2
9L	7027	6550010316158	SENSITIVITY DISCS DIAGNOSTIC AMPICILLIN 10 MICROGRAMS 500S	1
9L	7027	6550010316162	SENSITIVITY DISCS DIAGNOSTIC CHLORAMPHENICOL 30 MICROGRAMS 500S	1
9L	7027	6550010316163	SENSITIVITY DISCS DIAGNOSTIC ERYTHROMYCIN 15 MICROGRAMS 500S	1
9L	7027	6550010316166	SENSITIVITY DISCS DIAGNOSTIC GENTAMICIN 10 MICROGRAMS 500S	1
9L	7027	6550010316167	SENSITIVITY DISCS DIAGNOSTIC KANAMYCIN 30 MICROGRAMS 500S	1
9L	7027	6550010316170	SENSITIVITY DISC DIAGNOSTIC PENICILLIN G 10 UNITS 500S	1
9L	7027	6550010316171	SENSITIVITY DISCS DIAGNOSTIC POLYMIXIN B 300 UNITS 500S	1
9L	7027	6550010316173	SENSITIVITY DISCS DIAGNOSTIC TETRACYCLINE 30 MICROGRAMS 500S	1
9L	7027	6550010316435	DIFFERENTIATION DISK MICROORGANISM PARA-AMINO DIMETHYLANILINE300	1
9L	7027	6550010316436	DIFFERENTIATION DISKS MICROORGANISM PNEUMOCOCCUS 300S	1
9L	7027	6550010339865	FLUID THIOGLYCOLLATE MEDIUM DEHYDRATED 1/4LB(113.4 GRAM)	1
9L	7027	6550010440315	CHLORINE TEST TAB U/W 6630010440334 100 HERMETICALLY SEALED TAB	100
9L	7027	6550010462912	TEST KIT ENTEROBACTERIACEAE DIFFERENTIATION	1
9L	7027	6550010563378	CULTURE BROTH GN BROTH DEHYDRATED 1 LB	1
9L	7027	6550010572575	BLOOD GROUPING SERUM ANTI-D USP 10ML	12
9L	7027	6550010577364	CONTROL COOMBS TEST 10 ML BT LIQ REQUIRES REFRIG 2 TO 8 DEG C	5
9L	7027	6550010754011	FECAL SPECIMEN COLLECTION & PREPARATION KIT 9 COMPONENTS 20S	2
9L	7027	6550010894502	FIXATIVE CYTOLOGICAL AEROSOL SPRAY 60 ML 12S	1
9L	7027	6550011397510	SENSITIVITY DISKS DIAGNOSTIC OXACILLIN 1 MCG 500S	1
9L	7027	6550011397515	SENSITIVITY DISCS DIAGNOSTIC CLINDAMYCIN 50 DISKS/TUBE 10 TU/PG	1
9L	7027	6550011397516	SENSITIVITY DISCS DIAGNOSTIC VANCOMYCIN 30 MCG 500S	1
9L	7027	6550011621195	SENSITIVITY DISCS DIAGNOSTIC NEOMYCIN 30MCG/DISK 500 DISCS/PG	1
9L	7027	6550011621196	SENSITIVITY DISCS DIAGNOSTIC STREPTOMYCIN 10MCG 500 PER PACKAGE	1
9L	7027	6550012252034	CONTROL SERUM RH NEGATIVE 10 ML SUFFICIENT FOR 200 TESTS	2
9L	7027	6550013170288	BLOOD GP SERUM ANTI-A LIQ 10ML VI F/SLIDE/TUBE/MICROPLATE 15'S	1

9L	7027	6550013170289	BLOOD GROUPING SERUM ANTI-B 10ML VI F/SLIDE/TUBE/MICROPLATE 15'S	1
9L	7027	6550013234630	BACTERIOLOGICAL SPECIMEN COLLECTION & TRANSPORTATION SYSTEM 12S	2
9L	7027	6550013438993	BLOOD GROUPING SERUM ANTI-A & B LIQUID W/DROPPER 10 ML BT 15'S	1
9L	7027	6550013625324	CONTROL SET HEMOGLOBIN 30 COMPONENTS	1
9L	7027	6550014176006	ALBUMIN BOVINE SERUM REAGENT 22% 10ML	6
9L	7027	6550014352623	SODIUM CHLORIDE SOLUTION BLD BANK SALINE 20 LITER W/SPIGOTS	1
9L	7027	6630001267503	PIPET DILUENT BLOOD LAB DISP WHITE CORP&PLATELET W/O TUBING 200S	3
9L	7027	6630001451534	TUBE BLOOD COLLECTING VACUUM 7ML WITH SODIUM FLUORIDE 100S	2
9L	7027	6630002999838	BULB BLOOD SAMPLE CAPILLARY TUBE RUBBER BLACK 8MM DIA 15MM 100S	1
9L	7027	6630010673827	COMPARATOR COLOR BLOCK TYPE 6.8-8.2PH 8.5X5.5X4.5 IN W/CASE	4
9L	7027	6630011269960	COAGULATION TIMER UNIT PLASMA 120/230V 50/60HZ OR 230V 50/60HZAC	1
9L	7027	6630013628299	WATER SAMPLING TEST REAGENT COLIFORM 200S	1
9L	7027	6630013789660	HOLDER BLOOD COLLECTING TU PLAS UNIVERSAL HOLDER F/VENOJECT1000S	1
9L	7027	6630014112405	ANALYZER CLINICAL CHEMISTRY AMPEROMETRIC & POTENTIOMETRIC	1
9L	7027	663002L000325	ANALYZER CHEMISTRY ACA IV	1
9L	7027	6640000016670	LID ANAEROBIC CULTURE APPARATUS PLASTIC	1
9L	7027	6640001138336	STIRRER-HOT PLATE MAGNETIC LABORATORY 120 VOLT 50-60 HZ AC	1
9L	7027	6640001451150	INDICATOR OXYGEN ANAEROBIC CULTURE APPARATUS DISPOSABLE 100S	5
9L	7027	6640001451180	CENTRIFUGE LABORATORY SMALL 115V 60HZ AC CONICAL SINGLE PHASE	1
9L	7027	6640001655726	RACK TEST TUBE LABORATORY EPOXY COATED WIRE 40 TUBE	2
9L	7027	6640002400035	DISH CULTURE PETRI TOP & BOTTOM COMPLETE DISP 15 X 100 MM 500S	3
9L	7027	6640002998490	RACK TEST TUBE LAB HEMOGLUTINATION CRS 90 TUBE	2
9L	7027	6640002998493	WASH BOTTLE LABORATORY 250 ML PLASTIC POLYETHYLENE 2.5" DIA	4
9L	7027	6640004097000	BULB DROPPING PIPET RUBBER 3ML LOAD CAPACITY .188" TUBE OD 12S	1
9L	7027	6640004181000	CLAMP TEST TUBE STODDARD DESIGN FINGER GRIP INCLUDED 1.5" JAW	2
9L	7027	6640004200000	CYLINDER GRADUATED LABORATORY 100 ML CAP GLASS C18 POUR-OUT	2
9L	7027	6640004223820	TRAY BIOLOGICAL STAINING DISH GLASS 0-300 DEG C F/20 1X3IN SLIDE	1
9L	7027	6640004260315	FORCEPS MICROSCOPE SLIDE CARBON STEEL O/A TWEEZER 130MM L	1
9L	7027	6640004286050	CAN PETRI CULTURE DISH	2
9L	7027	6640004361000	PAPER FILTER QUALITATIVE 250MM DIAMETER MEDIUM NOT FOLDED 100S	1
9L	7027	6640004397375	SPATULA LABORATORY 8 INCH BLADE	2
9L	7027	6640006180073	TUBE CAPILLARY MICROHEMATOCRIT GLASS 1.16MM OD 75 MM LONG 100S	5
9L	7027	6640007650621	WATER BATH ELECTRIC CRS RECT 115V 50/60HZ AC 30TO100DEG CELSIUS	1
9L	7027	6640008891594	JARS AND SHIPPING BOX HISTOPATHOLOGICAL SPECIMEN DISPOSABLE	3
9L	7027	6640008891712	FILLER PIPET RUBBER 2"DIA 3.5"LG BALL VALVE TYPE 3 VALVES	1
9L	7027	6640008897023	FUNNEL COMMON LAB POLYPROPYLENE RIBBED 100 MM INSIDE DIAMETER	3
9L	7027	6640009261260	STIRRING BAR SET MAGNETIC PERMANENT TETRAFLUOROETHYLENE COATED	1
9L	7027	6640009261290	VORTEX MIXER LABORATORY SINGLE CUP 115V 50/60HZ AC	1
9L	7027	6640009267655	JAR ANAEROBIC CULTURE APPARATUS PLASTIC BREWER H1 ANAEROBIC	1
9L	7027	6640009309034	CENTRIFUGE LABORATORY 15ML TU 115V 650/60 HZ 12X13.5IN 135 WATTS	1
9L	7027	6640009338739	CATALYST ANAEROBIC CULTURE APPARATUS GRANULAR 10S	1
9L	7027	6640009354270	FLASK ERLENMEYER GRADUATED BOROSILICATE GLASS 500 ML	2
9L	7027	6640009356863	GENERATOR GAS ENVELOPE IMMEDIATE CONSUMPTION 100S	1
9L	7027	6640009736173	BOX MICROSCOPE SLIDE CHIPBOARD 20 SLIDE HINGED COVER CLOSURE	6
9L	7027	6640009824243	SHAKING MACHINE LAB BLOOD COLLECTING TUBE 115V 60HZ AC 12 TUBE	1
9L	7027	6640010112102	PIPET AUTOMATIC MICRO CORROSION-RESISTING METAL 20 MICROLITER	1
9L	7027	6640010112104	PIPET AUTOMATIC ALUMINUM ALLOY M27 DISPOSABLE TIP 50 MCLTR GREEN	1
9L	7027	6640010112105	PIPET AUTOMATIC ALUMINUM ALLOY M27 DISPOSABLE TIP 100 MCLTR BLUE	1
9L	7027	6640010112106	PIPET AUTOMATIC ALUMINUM ALLOY M27 DISP TIP 200 MCLTR BROWN	1
9L	7027	6640010112107	PIPET AUTOMATIC ALUMINUM ALLOY M27 DISPOSABLE TIP 500 MCLTR RED	1
9L	7027	6640010169432	COUNTER BLOOD CELLS AUTOMATIC DIGITAL 115VOLT 50-60HZ AC	1
9L	7027	6640010253176	LOOP INOCULATING LABORATORY QUANTITATIVE 0.01ML	1

9L	7027	6640010303099	STERILIZER INOCULATING LOOP LABORATORY INFRARED HEAT115V60HZ AC	1
9L	7027	6640010313139	DISH CULTURE PETRI TOP & BOTTOM COMPLETE DISPOSABLE 100S	1
9L	7027	6640010884246	PIPET DROPPING PLASTIC DISPOSABLE 6 INCHES LONG 3.5 ML 500S	5
9L	7027	6640010948408	TIP PIPET NONSTERILE DISP 70 ML LONG PLAS POLYPROPYLENE WH 1000S	2
9L	7027	6640010994066	TUBE LAB SHIPPING/STORING PLASTIC K8 W/SCREW CAP 8-10ML 1000S	1
9L	7027	6640011179692	LOOP INOCULATING LAB PLATINUM/RHODIUM SZ 0.41MM DELIVERS 0.001ML	2
9L	7027	6640011190013	TEST TUBE 12 BY 75 MM DISPOSABLE GLASS BOROSILICATE 1000S	1
9L	7027	6640011405269	ROTATOR LABORATORY VARIABLE SPEED 120 VOLT 60 HZ AC	1
9L	7027	6640011494117	STAND TRANSFER BLOOD COLLECTING BAG	1
9L	7027	6640012544187	BOX MICROSCOPE SLIDE PLAS ACCOMODATES 75X25MM SLIDE UNBREAKABL25	2
9L	7027	6640012903012	PIPET SEROLOGICAL M18 GENERAL PURPOSE 1MM CAPACITY 12S	1
9L	7027	6640012904663	PIPET SEROLOGICAL GLASS M18 GENERAL PURPOSE 10ML CAPACITY 12S	1
9L	7027	6640012911204	PIPET SEROLOGICAL GLASS GENERAL PURPOSE 8MM OD 5MM CAPACITY 12'S	1
9L	7027	6640013297539	BEAKER LAB GRIFFIN GLASS B1 LOW W/SPOUT 102-112MM H 400ML CAP12S	0.2
9L	7027	6640013598061	PIPET BACTERIOLOGICAL GLASS FLINT M2 PASTEUR146.05MM LG 250S	1
9L	7027	6640014156045	INCUBATOR BACTERIOL	1
9L	7027	6645012129474	TIMER INTERVAL THREE TIMING CHANNELS ONE CLOCK CHANNEL 120V60HZ	1
9L	7027	6650004317500	DISK MICROMETER MICROSCOPE EYEPIECE GLASS 35MM RULED SCALE	1
9L	7027	6650009333218	REFRACTOMETER HAND IMMERSION TYPE ALUMINUM 3SCALE DIRECT READING	1
9L	7027	6670004017195	BALANCE TRIP LABORATORY HARVARD DOUBLE BEAM 2000 GRAM CAPACITY	1
9L	7027	6670004018830	WEIGHT SET BALANCE HARVARD TRIP 100 GM TO 1000 GM	1
9L	7027	6810001366000	POTASSIUM HYDROXIDE ACS PELLET 4OZ AVOIRDUPOIS	1
9L	7027	6810002998506	HYDROGEN PEROXIDE ACS LIQUID 4OZ 32.0 MAX BY WT HYDROGEN PRXDE	1

COG	AMAL	NSN	NOMEN	QTY
1I	7019	0102LF0159800	BLOOD DONOR CARD, DD-572, 100s	1
9L	7019	6510011139208	PREPARATION KIT BLOOD DONOR STERILE 20S	3
9L	7019	6515005842926	BALANCE AUTO SHUTOFF BLD COLLECTING-DISPENSING BAG 450ML CAP	1
9L	7019	6515011281407	BLOOD RECIPIENT SET INDIRECT TRANSFUSION Y TYPE NONTOXIC 48S	2
9L	7019	6515014328272	ADAPTER HYPODERMIC NEEDLE TO TUBIN U/W TERUFLEX BLD GAS 3000S	1
9L	7019	6515014476868	BLOOD COLLECTING-DISPENSING BAG AND DONOR SET PLAS 4000ML	2
9L	7019	6530004776720	STERILIZATION TEST STRIP SET BACTERIAL SPORE BACILLUS SUBTILIS25	1
9L	7019	6530013695892	POWER SUPPLY ELECTRICAL MEDICAL EQUIP UNINTERRUPTIBLE SOURCE	1
9L	7019	6550001391321	FORMALDEHYDE SOLUTION 37% 1 PT(473 ML)	2
9L	7019	6550010440315	CHLORINE TEST TAB U/W 6630010440334 100 HERMETICALLY SEALED TAB	4
9L	7019	6550012114779	INTESTINAL PROTOZOA STAINING KIT 8 COMPONENTS	1
9L	7019	6550012628744	TEST SLIDE UREA NITROGEN DETERMINATION 25 TESTS U/W6630013327886	1
9L	7019	6550012747215	TEST SLIDE CHOLESTEROL DETERMINATION DISP QS 25	1
9L	7019	6550012747216	TEST SLIDE CHLORIDE DETERMINATION U/W 6630-01-332-7886 F/25 TEST	1
9L	7019	6550012747217	TEST SLIDE CARBON DIOXIDE DETERMINATION U/W6630-01-332-7886 25'S	1
9L	7019	6550012747218	TEST SLIDE POTASSIUM DETERMINATION SUFFICIENT FOR 25 TESTS	1
9L	7019	6550012747219	TEST SLIDE SODIUM DETERMINATION QS F/25 TESTS U/W 6630013327886	1
9L	7019	6550012748513	REFERENCE STANDARD SET BLOOD CHEM 25 COMP F/6630-01-332-7886	1
9L	7019	6550012748514	REFERENCE STANDARD SOL SODIUM POTASSIUM CHLORIDE&CO2 10ML VIAL4	1
9L	7019	6550012751379	TEST SLIDE GLUCOSE DETERMINATION QS F/25 TESTS U/W6630013327886	1
9L	7019	6550012779426	TEST SLIDE ALANINE AMINOTRANSFERASE QS 25 TEST U/W6630013327886	1
9L	7019	6550012779427	TEST SLIDE ASPARTATE AMINOTRANSFERASE U/W 6630013327886 25TESTS	1
9L	7019	6550012779428	TEST SLIDE CREATINE KINASE DET DISP U/W 6630013327886 25 TESTS	1
9L	7019	6550012779429	TEST SLIDE ALKALINE PHOSPHATASE DETERMINATION DISP QS 25 TESTS	1
9L	7019	6550012779430	TEST SLIDE AMYLASE DET 25 TESTS U/W NSN 6630013327886	1
9L	7019	6550012779431	TEST SLIDE LACTATE DEHYDROGENASE DETERMINATION DISPOSABLE QS 25	2
9L	7019	6550012867586	TEST SLIDE HIGH DENSITY LIPOPROTEIN DETERMINATION 25 SLIDES/PG	1
9L	7019	6550012867587	TEST SLIDE TOTAL BILIRUBIN DETERMINATION 25TEST U/W6630013327886	1
9L	7019	6550012867588	TEST SLIDE TOTAL PROTEIN DETERMINATION 25 TEST U/W6630013327886	1
9L	7019	6550012867589	TEST SLIDE TRIGLYCERIDE DETERMINATION 25 SLIDES PER PACKAGE	1
9L	7019	6550013103236	CONTROL FLUID 12S	1
9L	7019	6550013103237	CONTROL HUMAN SERUM F/DRY CHEM SLIDE TEST PROCEDURES NORMAL 12	1
9L	7019	6550013170288	BLOOD GP SERUM ANTI-A LIQ 10ML VI F/SLIDE/TUBE/MICROPLATE 15'S	0.2
9L	7019	6550013170289	BLOOD GROUPING SERUM ANTI-B 10ML VI F/SLIDE/TUBE/MICROPLATE 15'S	0.25
9L	7019	6550013299842	BLOOD GROUPING SERUM BT W/DROPPER 10 ML RH POS/NEG DET 15'S	6
9L	7019	6550013438993	BLOOD GROUPING SERUM ANTI-A & B LIQUID W/DROPPER 10 ML BT 15'S	1
9L	7019	6630001267503	PIPET DILUENT BLOOD LAB DISP WHITE CORP&PLATELET W/O TUBING 200S	1
9L	7019	6630001451534	TUBE BLOOD COLLECTING VACUUM 7ML WITH SODIUM FLUORIDE 100S	1
9L	7019	6630010673827	COMPARATOR COLOR BLOCK TYPE 6.8-8.2PH 8.5X5.5X4.5 IN W/CASE	1
9L	7019	6630010685256	PIPET-DILUENT BLOOD LABORATORY PLAS .025 ML CAPACITY GLASS 100S	5
9L	7019	6630013327886	ANALYZER CLINICAL CHEMISTRY 110/240V 50/60HZ AC 7INX42INX14IN	1
9L	7019	6630013628299	WATER SAMPLING TEST REAGENT COLIFORM 200S	1
9L	7019	6630013789660	HOLDER BLOOD COLLECTING TU PLAS UNIVERSAL HOLDER F/VENOJECT1000S	1
9L	7019	6640000108363	BOTTLE SCREW CAP NARROW MOUTH RECTANGULAR 2.50GAL PLASTIC	1
9L	7019	6640001352994	BOTTLE SCREW CAP WIDE MOUTH ROUND 4 OZ 12S	12
9L	7019	6640001451180	CENTRIFUGE LABORATORY SMALL 115V 60HZ AC CONICAL SINGLE PHASE	1
9L	7019	6640001655726	RACK TEST TUBE LABORATORY EPOXY COATED WIRE 40 TUBE	2
9L	7019	6640002998490	RACK TEST TUBE LAB HEMOGLUTINATION CRS 90 TUBE	2
9L	7019	6640002998493	WASH BOTTLE LABORATORY 250 ML PLASTIC POLYETHYLENE 2.5" DIA	4
9L	7019	6640004097000	BULB DROPPING PIPET RUBBER 3ML LOAD CAPACITY .188" TUBE OD 12S	1
9L	7019	6640004180000	CLAMP RUBBER TUBING SHUTOFF PINCHCOCK MOHR DESIGN .625" TUBE OD	2

9L	7019	6640004181000	CLAMP TEST TUBE STODDARD DESIGN FINGER GRIP INCLUDED 1.5" JAW	2
9L	7019	6640004200000	CYLINDER GRADUATED LABORATORY 100 ML CAP GLASS C18 POUR-OUT	2
9L	7019	6640004223820	TRAY BIOLOGICAL STAINING DISH GLASS 0-300 DEG C F/20 1X3IN SLIDE	1
9L	7019	6640004260315	FORCEPS MICROSCOPE SLIDE CARBON STEEL O/A TWEEZER 130MM L	1
9L	7019	6640004361000	PAPER FILTER QUALITATIVE 250MM DIAMETER MEDIUM NOT FOLDED 100S	2
9L	7019	6640004378000	PIPET VOLUMETRIC 5 ML	5
9L	7019	6640004401250	STAND LABORATORY APPARATUS SUPPORT BASE 6 BY 11 INCHES	1
9L	7019	6640007826007	JAR PIPET PLASTIC POLYETHYLENE H10 SOAKING	1
9L	7019	6640008891594	JARS AND SHIPPING BOX HISTOPATHOLOGICAL SPECIMEN DISPOSABLE	1
9L	7019	6640008891712	FILLER PIPET RUBBER 2"DIA 3.5"LG BALL VALVE TYPE 3 VALVES	1
9L	7019	6640008897023	FUNNEL COMMON LAB POLYPROPYLENE RIBBED 100 MM INSIDE DIAMETER	1
9L	7019	6640009261290	VORTEX MIXER LABORATORY SINGLE CUP 115V 50/60HZ AC	1
9L	7019	6640009267673	WASHER PIPET AUTOMATIC SIPHON TUBE TYPE SINGLE WALL CYLINDRICAL	1
9L	7019	6640009309034	CENTRIFUGE LABORATORY 15ML TU 115V 650/60 HZ 12X13.5IN 135 WATTS	1
9L	7019	6640009821294	TRAY AND RACK LABORATORY PLASTIC 14X11.5X2" W/ALUMINUM HANDLE	1
9L	7019	6640010104122	SEALER-HOLDER CAPILLARY TUBE PLASTIC DISPOSABLE 6S	1
9L	7019	6640010948408	TIP PIPET NONSTERILE DISP 70 ML LONG PLAS POLYPROPYLENE WH 1000S	1
9L	7019	6640010994066	TUBE LAB SHIPPING/STORING PLASTIC K8 W/SCREW CAP 8-10ML 1000S	1
9L	7019	6640011190013	TEST TUBE 12 BY 75 MM DISPOSABLE GLASS BOROSILICATE 1000S	1
9L	7019	6640011479563	BASKET TEST TUBE 6X6X6 IN PLASTIC POLYPROPYLENE TAPERED SIDES	1
9L	7019	6640012903012	PIPET SEROLOGICAL M18 GENERAL PURPOSE 1MM CAPACITY 12S	1
9L	7019	6640012904663	PIPET SEROLOGICAL GLASS M18 GENERAL PURPOSE 10ML CAPACITY 12S	1
9L	7019	6640012911204	PIPET SEROLOGICAL GLASS GENERAL PURPOSE 8MM OD 5MM CAPACITY 12'S	1
9L	7019	6640013623914	INCUBATOR DRY HEAT 120V 50/60HZ 13.5IN W 16.5IN H MDL 120	1
9L	7019	6645012129474	TIMER INTERVAL THREE TIMING CHANNELS ONE CLOCK CHANNEL 120V60HZ	1
9L	7019	6650009354247	SHIELD OPTICAL MICROSCOPE VINYL 16X20" COLLAPSIBLE	1
9L	7019	6685004446500	THERMOMETER SELF INDICATING BIMETALLIC 0 TO 220 DEG FAHRENHEIT	3
9L	7019	6810001366000	POTASSIUM HYDROXIDE ACS PELLET 4OZ AVOIRDUPOIS	1
9L	7019	6810002998503	FERRIC CHLORIDE ACS LUMP 4 OUNCES	0.5
9L	7019	6850011207996	DETERGENT TABLETS LAB GLASSWARE PH RANGE 9-9.5 100S	1
9Q	7019	7540001818344	FORM PRINTED LABORATORY REPORT MISCELLANEOUS 3PART 100S	1
9Q	7019	7540001818351	FORM PRINTED MICROBIOLOGY I STD FORM 553 3 PARTS 100S	1
9Q	7019	7540001818354	FORM PRINTED LABORATORY REPORT HEMATOLOGY 3PART 100S	2
9Q	7019	7540001818355	FORM PRINTED LABORATORY REPORT URINALYSIS 3PART 100S	2
9Q	7019	7540001818357	FORM PRINTED SEROLOGY STD FORM 551 3 PARTS 100S	2
9Q	7019	7540001818358	FORM PRINTED 100S	2
9Q	7019	7540006344159	FORM PRINTED CLINICAL RECORD-BLOOD TRANSFUSION STD FRM 518 100S	1

COG	AMAL	NSN	NOMEN	QTY
9L	7018	6130010701500	POWER SUPPLY 115 VOLT 60 HZ AC	1
9L	7018	6515004312890	LANCET FINGER BLEEDING 1.25X0.375" 5/32" MAXIMUM BLADE LENGTH12S	1
9L	7018	6515007826482	SWAB CULTURE CALCIUM ALGINATE WOOL TIPPED 100S	1
9L	7018	6515010032368	NEEDLE HYPO C5A BLD COLL 20GAX1.50" REG THD MULTIPLE SMPL 1000S	0.2
9L	7018	6515011467794	TOURNIQUET NONPNEUMATIC ADULT 14X1" BLD TAKING DSGN RUBBER O/A	2
9L	7018	6530000756636	SPECIMEN KIT URINE	0.1
9L	7018	6550001539968	GIEMSAS STAIN LIQ PACKAGED TOGETHER W/ONE25GM BT BUFFER SALT50MI	1
9L	7018	6550001595011	TEST KIT SYPHILIS DETECTION BREWER TYPE 500 TESTS	0.1
9L	7018	6550001656538	TEST KIT OCCULT BLOOD DETERMINATION 100 TESTS	1
9L	7018	6550002619053	GRAM STAINING KIT	1
9L	7018	6550007644729	WRIGHT'S STAIN LIQ 1 QT BOTTLE ROMANOWSKI TYPE	1
9L	7018	6550010054375	TEST KIT MONONUCLEOSIS DETERMINATION 25 TESTS	1
9L	7018	6550010498628	CONTROL RAPID PLASMA REAGIN CARD LYOPHILIZED SYPHILLIS DISP 10S	2
9L	7018	6550011611859	BACTERIOLOGICAL SPECIMEN COLLECTION & TRANSPORTATION SYSTEM 100	1
9L	7018	6550012360805	TEST STRIPS AND COLOR CHART GLUCOSE IN BLOOD 50 STRIPS/BOTTLE	1
9L	7018	6550013384677	TEST STRIPS&COLOR CHART BILIRUBIN BLD GLUCOSE KETONE LEUKOC 100S	1
9L	7018	6630001451137	TUBE BLOOD COLLECTING VACUUM 7ML W/O ANTICOAGULANT NONSTERILE1(	1
9L	7018	6630004276850	CHAMBER COUNTING BLOOD CELLS REPLACEMENT F/NSN 6630-00-427-7000	2
9L	7018	6630004277000	HEMACYTOMETER SET COMPONENT QUANTITY 9	1
9L	7018	6630011198575	TUBE BLOOD COLLECTING GLASS 7ML 15% SOL EDTA (K3) STER 100S	1
9L	7018	6630012309964	HOLDER BLOOD COLLECTING TUBE PLAS POLYPROP 2.438"LG .750"ID 10'S	1
9L	7018	6630013884098	COMPARATOR COLOR USE W/6630-01-362-8299 &6630-01-357-5910 100ML	1
9L	7018	6640000744191	SLIDE MICROSCOPE PLAIN FROSTED END 75.4 X 25 MM 72S	1
9L	7018	6640002999807	IMMERSION OIL MICROSCOPY 1 OZ BOTTLE	1
9L	7018	6640004188010	COUNTER BLOOD CELLS DIFFERENTIAL REST DEVICE KEY QUANTITY 8	1
9L	7018	6640004276875	COVER GLASS MICROSCOPE SLIDE HEMACYTOMETER SET 6640-00-427-7000	4
9L	7018	6640004301000	JAR BIOLOGICAL STAINING COPLIN GLASS SODA LIME H5 10 SLIDES	1
9L	7018	6640006180066	COVER GLASS MICROSCOPE SLIDE 22 MM SQUARE 1 OZ	10
9L	7018	6640006841345	BOX MICROSCOPE SLIDE PLASTIC 25 SLIDE HINGED/FRICTION FIT COVER	2
9L	7018	6640009370760	PAPER LENS PAD WHITE BIBULOUS PAPER 6IN LONG 4IN WIDE PERFORATED	1
9L	7018	6640010689613	TUBE CAPILLARY MICRO-HEMATOCRIT GLASS HEPARINIZED 32 MM LG 500S	1
9L	7018	6640011536786	BAG WATER SAMPLE POLYETHYLENE 3 X 7 IN 100S	6
9L	7018	6640012831435	CENTRIFUGE LABORATORY 11500 RPM ELECTRIC DC 9V 8.2X3.4X2.3"	1
9L	7018	6650014121040	MICROSCOPE OPTICAL 115/230V 50/60 HZ AC W/DUST COVER LAMP & FUSE	1
9L	7018	7520012496421	MARKER TUBE TYPE BLK WATER RESIST PERMANENT INK FINE FILT PT 10S	1

COG	AMAL	NSN	NOMEN	QTY
9L	7026	6130010701500	POWER SUPPLY 115 VOLT 60 HZ AC	1
9L	7026	6515004312890	LANCET FINGER BLEEDING 1.25X0.375" 5/32" MAXIMUM BLADE LENGTH12S	1
9L	7026	6515007826482	SWAB CULTURE CALCIUM ALGINATE WOOL TIPPED 100S	1
9L	7026	6515010032368	NEEDLE HYPO C5A BLD COLL 20GAX1.50" REG THD MULTIPLE SMPL 1000S	5
9L	7026	6515011467794	TOURNIQUET NONPNEUMATIC ADULT 14X1" BLD TAKING DSGN RUBBER O/A	4
9L	7026	6530000756636	SPECIMEN KIT URINE	3
9L	7026	6550001539968	GIEMSAS STAIN LIQ PACKAGED TOGETHER W/ONE25GM BT BUFFER SALT50ML	4
9L	7026	6550001595011	TEST KIT SYPHILIS DETECTION BREWER TYPE 500 TESTS	1
9L	7026	6550001656538	TEST KIT OCCULT BLOOD DETERMINATION 100 TESTS	3
9L	7026	6550002619053	GRAM STAINING KIT	3
9L	7026	6550007644729	WRIGHT'S STAIN LIQ 1 QT BOTTLE ROMANOWSKI TYPE	6
9L	7026	6550010054375	TEST KIT MONONUCLEOSIS DETERMINATION 25 TESTS	3
9L	7026	6550010498628	CONTROL RAPID PLASMA REAGIN CARD LYOPHILIZED SYPHILLIS DISP 10S	3
9L	7026	6550011611859	BACTERIOLOGICAL SPECIMEN COLLECTION & TRANSPORTATION SYSTEM 100S	2
9L	7026	6550012360805	TEST STRIPS AND COLOR CHART GLUCOSE IN BLOOD 50 STRIPS/BOTTLE	2
9L	7026	6550013384677	TEST STRIPS&COLOR CHART BILIRUBIN BLD GLUCOSE KETONE LEUKOC 100S	10
9L	7026	6630001451137	TUBE BLOOD COLLECTING VACUUM 7ML W/O ANTICOAGULANT NONSTERILE100	10
9L	7026	6630004276850	CHAMBER COUNTING BLOOD CELLS REPLACEMENT F/NSN 6630-00-427-7000	1
9L	7026	6630004277000	HEMACYTOMETER SET COMPONENT QUANTITY 9	1
9L	7026	6630011198575	TUBE BLOOD COLLECTING GLASS 7ML 15% SOL EDTA (K3) STER 100S	10
9L	7026	6630012309964	HOLDER BLOOD COLLECTING TUBE PLAS POLYPROP 2.438"LG .750"ID 10'S	1
9L	7026	6630013884098	COMPARATOR COLOR USE W/6630-01-362-8299 &6630-01-357-5910 100ML	1
9L	7026	6640000744191	SLIDE MICROSCOPE PLAIN FROSTED END 75.4 X 25 MM 72S	10
9L	7026	6640002999807	IMMERSION OIL MICROSCOPY 1 OZ BOTTLE	2
9L	7026	6640004188010	COUNTER BLOOD CELLS DIFFERENTIAL REST DEVICE KEY QUANTITY 8	1
9L	7026	6640004276875	COVER GLASS MICROSCOPE SLIDE HEMACYTOMETER SET 6640-00-427-7000	6
9L	7026	6640004301000	JAR BIOLOGICAL STAINING COPLIN GLASS SODA LIME H5 10 SLIDES	1
9L	7026	6640006180066	COVER GLASS MICROSCOPE SLIDE 22 MM SQUARE 1 OZ	10
9L	7026	6640006841345	BOX MICROSCOPE SLIDE PLASTIC 25 SLIDE HINGED/FRICTION FIT COVER	1
9L	7026	6640009370760	PAPER LENS PAD WHITE BIBULOUS PAPER 6IN LONG 4IN WIDE PERFORATED	2
9L	7026	6640010689613	TUBE CAPILLARY MICRO-HEMATOCRIT GLASS HEPARINIZED 32 MM LG 500S	2
9L	7026	6640011536786	BAG WATER SAMPLE POLYETHYLENE 3 X 7 IN 100S	9
9L	7026	6640012831435	CENTRIFUGE LABORATORY 11500 RPM ELECTRIC DC 9V 8.2X3.4X2.3"	1
9L	7026	6650014121040	MICROSCOPE OPTICAL 115/230V 50/60 HZ AC W/DUST COVER LAMP & FUSE	1
9L	7026	7520012496421	MARKER TUBE TYPE BLK WATER RESIST PERMANENT INK FINE FILT PT 10S	1

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APPENDIX C. NAVMEDLOGCOM EVALUATIONS

TABLE 3-6. NAVMEDLOGCOM CHEMISTRY EVALUATION

TEST	ABBOTT	PICCOLO	I-STAT	CHIRON	ACE	BM
Albumin	X	X		X		
Alkaline phosphatase	X	X		X		
ALT	X	X		X	X	X
AMMONIA	X			X		
Amylase	X	X		X	X	X
AST	X	X		X	X	X
Direct Bilirubin	X	X		X	X	X
Total Bilirubin	X	X		X	X	X
Calcium	X	X		X		
Carbon dioxide	X		X	X		
Cholesterol	X	X		X	X	X
Chloride	X		X	X		
CK	X			X	X	X
Creatinine	X	X		X	X	X
CSF Protein	X					
CSF Glucose	X					
LDL	X			X		
HDL	X			X		X
GGT	X	X		X	X	X
Glucose	X	X	X	X	X	X
Iron	X			X		
LD-1	X					
LD	X					
Magnesium	X			X		
Phosphorus	X			X		
Potassium	X		X			
Sodium	X		X			
TIBC	X					
Total Protein	X	X		X		
Triglyceride	X				X	X
UIBC	X				X	X
Urea	X	X	X		X	X
Uric Acid	X	X		X		
Urine Protein	X					
pH			X			
Blood Gases			X			
Ionized Calcium			X			
BUN			X	X	X	
HCT			X			
HGB (calculated)			X			X
Anion Gap			X			
Bicarbonate (calculated)			X			
Acid Phosphatase				X		
Tests per hour	**300**	**25**	**25**	**180**	**153**	**50**

TABLE 3-7. NAVMEDLOGCOM HEMATOLOGY EVALUATION

TEST	CELL DYN 1700	MD 11	ACT	ONYX	SP LITE	SPIRIT	SP CAP	K-1000	K-4500
WBC	X	X	X	X	X	X	X	X	X
RBC	X	X	X	X	X	X	X	X	X
HGB	X	X	X	X	X	X	X	X	X
HCT	X	X	X	X	X	X	X	X	X
MCV	X	X	X	X	X	X	X	X	X
MCHC	X	X	X	X	X	X	X	X	X
MCH	X	X	X	X	X	X	X	X	X
PLT	X	X	X	X	X	X	X	X	X
RDW	X			X	X	X	X		X
MONO #	X			X	X	X	X		X
GRAN #	X			X	X	X	X		X
LYMPH#	X			X	X	X	X		X
DIFF									
% LY	X	X		X	X	X	X		X
% MO	X	X		X	X	X	X		X
% GR	X	X		X	X	X	X		X
% EOS	X			X					
% BASO	X			X					

TABLE 3-8. NAVMEDLOGCOM CHEMISTRY EVALUATION

TEST	ABBOTT	PICCOLO	I-STAT	CHIRON	ACE	BM
Albumin	X	X		X		
Alkaline phosphatase	X	X		X		
ALT	X	X		X	X	X
AMMONIA	X			X		
Amylase	X	X		X	X	X
AST	X	X		X	X	X
Direct Bilirubin	X	X		X	X	X
Total Bilirubin	X	X		X	X	X
Calcium	X	X		X		
Carbon dioxide	X		X	X		
Cholesterol	X	X		X	X	X
Chloride	X		X	X		
CK	X			X	X	X
Creatinine	X	X		X	X	X
CSF Protein	X					
CSF Glucose	X					
LDL	X			X		
HDL	X			X		X
GGT	X	X		X	X	X
Glucose	X	X	X	X	X	X
Iron	X			X		
LD-1	X					
LD	X					
Magnesium	X			X		
Phosphorus	X			X		
Potassium	X		X			
Sodium	X		X			
TIBC	X					
Total Protein	X	X		X		
Triglyceride	X				X	X
UIBC	X				X	X
Urea	X	X	X		X	X
Uric Acid	X	X		X		
Urine Protein	X					
pH			X			
Blood Gases			X			
Ionized Calcium			X			
BUN			X	X	X	
HCT			X			
HGB (calculated)			X			X
Anion Gap			X			
Bicarbonate (calculated)			X			
Acid Phosphatase				X		
Tests per hour	**300**	**25**	**25**	**180**	**153**	**50**

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